7.5 DATA MINING FOR TROPICAL CYCLONE INTENSITY PREDICTION

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ABSTRACT

Tropical cyclone (TC) intensity prediction is far more challenging than the corresponding TC track prediction. One of the reasons is the lack of understanding of the coupling relationships of the physical processes controlling TC intensification. Data mining provides potential tools for relationship exploration from the ever-increasing amount of TC data. The data mining tools and algorithms require process-related features from raw observational data such as the TC best track data, TRMM data for 3D rainfall and 2D surface information. The data mining tools and algorithms can search for hidden relationships among the underlying features by means of statistical and logical inferences.

In this article, we describe the data, definitions of features from the data, tools for data exploration, and several important results.

1. INTRODUCTION

Accurate tropical cyclone (TC) intensity prediction is a far more challenging research topic than the relevant track prediction. The ensemble of 18 worldwide track models can forecast in 9 times out of 10 such a track that spans the true path of tropical cyclones at all forecast times up to 72 hours (Aberson 2001). On the contrary the best intensity forecast model so far (DeMaria and Kaplan 1994 and 1999) is still statistically based and can only explain 30%-50% variance in TC intensity. Many reasons can be accounted for the poor skill of the TC intensity forecasting (Wang and Wu 2004), such as inadequate observations about the TC structures, deficient understanding of the physical processes governing the intensity change, coarse model resolution, poor initial conditions etc.

Starting in 1998, the Tropical Rainfall Measurement Mission (TRMM) has carried the first space-born Precipitation Radar (PR) and produced for the first time 3D rainfall structures of tropical cyclones. Using these brand-new rainfall profiles near the TC eye walls, the convective tower theory in TC intensification (Riehl and Simpson 1958) has been reexamined by Kelley and Stout (2004). In their study, it was found that intensifying cyclones are more than twice as likely to have a convective tower in their eye walls as non-intensifying cyclones. For this, a convective tower was defined as a convective cell with at least 2 mm/hr precipitation rate at an altitude higher than 14 km.

Introduced in 1993, the association rule discovery (Agrawal et al. 1993) has attracted a lot of attention in helping business managers to deploy items and promote products. Moreover its use is not restricted to market basket analysis, but has been extended to a wide range of domains, such as web access patterns discovery (Chen et al. 1996) and building intrusion detection models (Lee et al. 1998). Tan et al (2002) applied it in abnormal ecological pattern discovery using a set of 12-year–long globally-gridded data of monthly averaged net primary production (NPP), soil moisture, temperature and precipitation. As far as we know, there is still no application of the association rule discovery in tropical cyclone intensity research.

In this paper we set our aim at unraveling the mystery of the coupling relationships of the physical processes controlling hurricanes (tropical cyclones with intensity above 64 knots) intensification because of the improvement of satellite based precipitation observations and the success of association rule discovery in various applications. In section 2 we will discuss the data and how to extract features for later use. In section 3 details of applying the Apriori-based association rule algorithm will be described. The result will be shown in section 3 followed by the discussion and future work in section 4.

2. DATA AND FEATURES

The TRMM PR level-2 TRMM 2A25 data product records the vertical structure of instantaneous rainfall retrieved from radiation attenuation. The website (http://www.eorc.jaxa.jp/TRMM/typhoon/index_e.htm) stores the TRMM 2A25 data associated with a particular tropical cyclone over the globe. The files are in HDF format. They contain scientific datasets (SDS) such as rain rate profile, profile of attenuation corrected reflectivity factor Z, near surface rain, near surface Z,

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and several parameters for the rainfall retrieval algorithm (Goddard DAAC 2004). Every SDS is at least a two-dimensional matrix with one dimension as the number of sweeps recorded in the file and the other as the number of radar beams in each sweep. Both rain rate profile and Z profile have an additional dimension to describe the 80 vertical layers evenly distributed from surface to 20 km in altitude. In this study, we have extracted features from the rain rate profile and the near surface rain SDS.

Sea surface temperature (SST) has been recognized as an important role in tropical cyclone intensification. In this paper we are using the optimally interpolated (OI) SST product derived from TRMM TMI by the Remote Sensing Systems, Inc., a world leader in processing and analyzing microwave data collected by SSM/I, TMI, AMSR, QSCAT and MSU. The OI TMI SSTs are available (latitudes 40S-40N) from January 1998 to the present. They cover the global region with regular grids with a pixel resolution of 0.25 deg (about 25 km). The binary data and accessing codes can be downloaded at http://www.ssmi.com/sst/microwave_oi_sst_browse.html .

The best track (BT) data we are using are from the NOAA National Hurricane Center (NHC) for the Atlantic basin (http://www.nhc.noaa.gov/pastall.shtml). It is an ASCII (text) file containing the 6-hourly (0000, 0600, 1200, 1800 UTC) center locations (latitude and longitude in tenths of degrees) and intensities (maximum 1-minute surface wind speeds in knots and minimum central pressures in millibars) for all tropical storms and hurricanes from 1851 through 2003 (Jarvinen et al. 1984). A small piece of FORTRAN code has been provided on the NHC/TPC Archive to read the best track data. It is so called the “best” because it has assembled multiple post-analysis estimates primarily based on multiple satellite observations. The nominal accuracy of the maximum wind estimates is 5 knots, since the wind values are rounded to this interval in the best track data (Jarvinen et al. 1984). Comparisons of satellite and aircraft reconnaissance intensity estimates suggest that the average error in the minimum central pressure is about 10 mbar, which corresponds to a wind error of 10-15 knots (DeMaria and Kaplan 1999).

There are totally 45 hurricanes recorded in NHC’s best track data during 1998 to 2003 in the Atlantic. Most hurricanes had been observed multiple times by TRMM except for the hurricane Noel (2001) which unfortunately had not been observed by TRMM at all. Due to the narrow swath of TRMM PR, sometimes TRMM observes the eye or/and eye wall near a tropical cyclone center, while at other times it only sees part of the far-away rain band curling around. Therefore in this study we only use 53 TRMM PR observations from a total of 25 hurricanes in the Atlantic from 1998 to 2003 where each observation captured at least half of the tropical cyclone around its center.

Using these 53 TRMM PR observations, we have extracted a total of 13 attributes (listed in Table 1) from the 3 data sets. The first 12 attributes in Table 1 are used as independent variables and the last attribute as the dependent variable. All the attributes are interpolated, if it is necessary, to the TRMM observation time. They are organized as a relational table with the 13 attributes as columns and the 53 observation cases as rows.

Among the 13 attributes, the observation date (JDT) and the observation time (JHR) are coded in TRMM PR 2A25 metadata. We first manually distinguish the location of tropical cyclones’ centers from the image of TRMM PR 2A25 data. The center location information is then used to form the 111km-radius circle and 111km-to-222km annuli around the centers. Later on using the near surface rain SDS in the 2A25 data set, four attributes – rain rate at the TC core area (cRR), the PIP index at the TC core area (cPP), rain rate at TC outer rings (oRR) and PIP at TC outer rings (oPP) are calculated following the method in Chang et al. (1995). The latitude of the TC location (LAT) is used in our study because we believe that the Coriolis force varies at different latitude and its strength may be one factor to affect the TC movement. The vertical rain rate profile SDS in the 2A25 product is used to extract the maximum height of rain cells with rain rate > 2 mm/hr (HGH). The averaged SST within the 1^o-radius core area (SST) is computed from the optimally interpolated TMI SST products of Remote Sensing System. The tropical cyclone’s center information has been reused to form the core area. The distance to the nearest land mass (LND) is calculated using the land marks in the OI TMI SST product. Other attributes such as the current intensity in terms of wind speed (V0), the moving speed of the TC (SPD), and the intensity change in the next 6 hours (FD6) are interpolated from NHC’s best track data.

Table 1. The 13 attributes used in our study.

Attr.	Description	Source
JDT	Julian date of the observation – peak value (253), unit: day, range: [-58, 67]	TRMM metadata
JHR	UTC hour of the observation, unit: hour, range: [0.067, 22.57]	TRMM metadata
LAT	Latitude of the TC center at the observation, unit: degree, range: [14.11, 35.47]	TRMM PR 2A25
LND	Distance from TC center to nearest land mass, unit: km, range: [0.00, 29.99]	TRMM TMI RSI
SST	Averaged sea surface temperature within 1^o of the TC center at the observation time, unit: ^oC, range: [24.53, 30.28]	TRMM TMI RSI

HGH	Max height of rain cells with rain rate >= 2mm/hr and inside TC at the observation time, unit: km, range: [8.50, 17.75]	TRMM PR 2A25
CRR	Averaged rain rate within 111km radius of the TC center at the observation time, unit: mm/hr, range: [0.804, 15.183]	TRMM PR 2A25
CPP	PIP index (the fraction of rain rate > 5 mm/hr over the total rain rate) within 111km radius of the TC center at the observation time, unitless, range: [0.286, 0.966]	TRMM PR 2A25
ORR	Averaged rain rate within the 111km to 222km annuli around TC center at the observation time, unit: mm/hr, range: [0.121, 6.74]	TRMM PR 2A25
OPP	PIP index within the 111km to 222km annuli around TC center at the observation time, unitless, range: [0.184, 0.888]	TRMM PR 2A25
SPD	Averaged translation speed in the past 6hr to the observation time, unit: km/hr, range: [2.41, 33.18]	NHC Best Track
V0	The TC intensity at the observation time, unit: knots, range: [45.28, 140.0]	NHC Best Track
FD6	The intensity change from the observation time to 6 hours later, unit: knots, range: [-23.93, 11.83]	NHC Best Track

3. ASSOCIATION RULE ALGORITHM

Association rule induction (Agrawal et al. 1993) is a powerful method for market basket analysis, which aims at finding regularities in the shopping behavior of customers. An association rule is a rule like "Z <= X, Y." The items X and Y are called antecedents in the rule and Z is the consequent. Two parameters are usually reported for association rules, namely the support, which estimates the probability p({X,Y,Z}), and the confidence, which estimates the probability p(Z|{X, Y}). This rule expresses an association between items X, Y, and Z. It states that if we pick a customer at random and find out that he selected items X and Y, we can be confident, with a high percentage (i.e., P(Z|{X,Y})), that he also selected item Z. An item set {X, Y, Z} is large (or frequent) if its support is greater than or equal to the user specified minimum support. An association rule Z <= X, Y is strong if it has a large support (i.e. {X, Y, Z} is large) and a high confidence.

Conceptually, the Apriori-based association rule algorithm is designed to deal with the boolean type data set. In detail each item can be regarded as a boolean type attribute, each transaction can be viewed as a row record, and the entire data set can be organized as a table with the boolean type attributes as the fields and the transactions as row records. The value of an attribute for a given record is "1" if the item corresponding to the attribute is present in the transaction corresponding to the record, and is "0" if the item is not in the transaction. Our data have richer attribute types, more specifically, they are all quantitative. Therefore how to convert these numeric attributes to boolean-type has become an important issue in our study.

Fortunately there is a straightforward solution. We can break down the attributes into several disjoint ranges. Thus instead of having just one field in the table for each attribute, we can have as many boolean fields as the number of attribute ranges for each attribute. The value of a boolean field will be "1" if the attribute has a value falling in the corresponding range, and "0" otherwise.

In our data the above idea has been implemented. The attribute V0 has been broken down into 8 ranges as 8 categories (see definitions from this website http://www.typhoon2000.ph/tropical_SS.htm): (1) tropical depression when $V0 \le 25 knots$, (2) tropical storm category A when $V0 \in [26,43] knots$, (3) tropical storm category B when $V0 \in [44,63] knots$, (4) hurricane category 1 when $V0 \in [64,82] knots$, (5) hurricane category 2 when $V0 \in [83,95] knots$, (6) hurricane category 3 when $V0 \in [96,113] knots$, (7) hurricane category 4 when $V0 \in [114,135] knots$, and (8) hurricane category 5 when $V0 > 135 knots$. There are totally 8 fields used to describe this attribute V0. Suppose the attribute V0 has a value of 35 knots, it can be represented as "0100 0000" where the second field has a "1" and other 7 fields have "0"s indicating V0 falls into the [26, 43] knots range. The remained 11 predictive attributes have been discretized and then transformed following the same method. Each of them (X) is broken down into three ranges by its own mean (m) and half of its standard deviation (s) over the entire observation sets, i.e., one range for such high values ("HI") when $X \ge m + \frac{s}{2}$, one range for such low values ("LO") when $X \le m - \frac{s}{2}$, and the third for such normal values ("N") that $m - \frac{s}{2} < X < m + \frac{s}{2}$. The dependent variable FD6 has been categorized into 3 groups too: one is the weakening group when $FD6 \le -5 knots$, one is the intensifying group when $FD6 \ge 5 knots$, and the other for the stable group when $-5 knots < FD6 < 5 knots$. Table 2 lists the mean and half of the standard deviation for each predictive attribute except V0.

Table 2. The statistics of each predictor.

Attr.	mean	std/2	min	max
JDT	0.9623	11.9968	-58.0000	67.0000
JHR	11.5999	3.2724	0.0670	22.5690
LAT	27.5170	3.1544	14.1100	35.4700
LND	15.5891	4.4658	0.0000	29.9900
SST	28.2219	0.6263	24.5300	30.2800
HGH	12.5566	1.2021	8.5000	17.7500
CRR	5.1356	1.4938	0.8040	15.1830
CPP	0.7773	0.0574	0.2860	0.9660
ORR	2.1999	0.6708	0.1210	6.7400
OPP	0.6278	0.0713	0.1840	0.8880
SPD	19.0881	3.5514	2.4100	33.1800

Finally the 13 numeric attributes are transformed into 44 boolean fields in a relational table with each of the 53 observation cases as a row. The transformed data can then be used in any of the association rule discovery implementations. Here we have chosen the implementation by Dr. Christian Borgelt. His program (http://fuzzy.cs.uni-magdeburg.de/~borgelt/apriori.html) takes the transformed data as input and outputs association rules or frequent item sets. The program is written in C. The executable versions for Linux and Window are prepared. For other platforms the source code is provided for compilation purpose. We have used the Linux version in our study.

Remember that our target is to find out the associations among multiple attributes and the intensity change in the next 6 hours so that the rules are restricted to those with only attribute FD6 appearing in the consequent. Using the minimum support as 9% and the minimum confidence as 80%, 5 rules have been found which indicate at what kind of a situation a TC will be intensified in the next 6 hours. Similarly, 18 rules have been found for the weakening situations, and 256 rules for the stable situations (see Table 3). The Borgelt's implementation only outputs rules in attribute indices. We wrote a small piece of script to convert attribute indices into attribute names and value range so that the rules can be understood easily. As an illustration, the first rule in Table 3 ("FD6=I <- HGH=H SPD=N") can be interpreted as "when the translation speed of a TC is in the normal range (not too fast and not too slow) and the rain cells of that TC reaches the high range (higher than 13.75 km), the TC will intensify in the next 6 hours with 80% probability."

From Table 3 we can see that the favorable situations when a TC will intensify in the next 6 hours are those:
(St.1) when a TC moves at normal speed and not too close to land mass, and the activity of convective rain in the TC is strong (with a height which exceeds the normal range).
(St.2) when a TC moves at normal speed and both the rain rate within the TC center and in the rain bands are small.

The favorable situations for TC weakening are those:
(St.3) when a TC moves into higher latitude (LAT>35.5^{o}) and cooler ocean (SST <27.6 ^{o}C) and the convective rain is dominant (OPP>70%) in the rain bands.

The favorable situations for TC with little intensity changes are those:
(St.4) when a TC is a slow mover (SPD < 15.5 km/hr), and the convective rain is not dominant in the rain bands (OPP<55%) and the maximal height of the convective towers inside the TC is in the normal range (11.25km<HGH<13.75km).
(St.5) when a TC moves fast (SPD > 26 km/hr) towards higher latitude away from land mass and the convective towers are lower (HGH<11.25km) and the precipitation activity within the TC center and around the rain band is not too active (both CRR and ORR are in normal range).

4. DISCUSSION AND FUTURE WORK

Considering the fact that the Apriori-base algorithm found much more rules for situations to keep TCs stable than those to intensify or weaken TCs, it is natural to ask why this happened. The major reason is that there are more training cases for stable TCs than intensifying or weakening TCs under the current discretization scheme on attribute FD6. Among the 53 observations there are 26 cases for stable TCs and only 12 cases for intensifying TCs and 15 cases for weakening TCs. Although we can change the separation criteria to increase cases for weakening TCs and intensifying TCs, we are not planning to do that because the nominal error in the NHC best track intensity records is 5 knots (Jarvinen et al. 1984). One thing we can do in the future is to increase the size of the entire data set by adding more observations.

One may notice that we chose a low value for the minimum support, i.e., 9%. This resulted from the process of transforming a numeric attribute to several boolean fields. If the number of intervals for a numeric attribute is large (here is 3 for most attributes), the support for any individual interval can be low. Hence we have to decrease the minimum support in order to select some rules involving this attribute. This reduced-support problem is inherited in every discretization situation. There have been some scientists working on this issue (Srikant and Agrawal 1996) and we will consider their results in our future work.

Discretization is a crucial step in our case. An experiment has been done on the same data set with a different set of discretization criteria. Instead of using the half of the standard deviations of the 11 predictors, we use the full length of the standard deviations to separate them around their means. 15 rules have been found for the situations favoring to intensify TCs, 5 for situations to weaken TC and 510 rules for keeping TCs stable.

Another thing one may notice is that in Table 3 there are some rules associated with each other. For instance, looking the three rules for weakening TCs in Table 3 (1) FD6=W <- LAT=H OPP=H (11.3%, 83.3%), (2) FD6=W <- SST=L OPP=H (11.3%, 83.3%), and (3) FD6=W <- LAT=H SST=L OPP=H (9.4%, 100.0%). Both antecedents in the first two rules are different subsets of the antecedent in the third rule. We really do not know if FD6=W is the consequence of a strong interaction of the triplet < LAT=H, SST=L, OPP=H> or because of a combination of two attributes (eg. <LAT=H, OPP=H> or <SST=L, OPP=H>). Currently we are investigating a method which is designed to select the multi-item associations that cannot be explained by the subset associations in the item set (Wu et al. 2003). This method fits the frequent item sets to a log-linear model by classic statistical theory and uses the fitted coefficients to determine the importance or interestingness of a frequent item set.

5. ACKNOWLEDGEMENTS

The authors would like to thank Dr. Christian Borgelt for providing his implementation of the Apriori algorithm. We would like to thank Mr. Owen Kelley for providing us the TRMM PR 2A25 data sets and the detail instruction on how to define the height of a rain cell in a TC. We also would like to thank Dr. Long Chiu and Dr. Daniel Barbara for informing us the PIP index method and the method of screening multi-item associations respectively.

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Appendix A

Table 3. Rules for TCs Intensifying/Weakening/Being stable in the next 6 hours

Intensifying Situation	
FD6=I <- HGH=H SPD=N (9.4%, 80.0%)	
FD6=I <- JDT=L LND=N (9.4%, 80.0%)	
FD6=I <- HGH=H LND=N SPD=N (9.4%, 80.0%)	St.1
FD6=I <- JDT=L LND=N SPD=N (9.4%, 80.0%)	
FD6=I <- CRR=L ORR=L SPD=N (9.4%, 80.0%)	St.2
Weakening Situation	
FD6=W <- V0=H4 CRR=H (9.4%, 80.0%)	
FD6=W <- V0=H4 LAT=L (9.4%, 80.0%)	
FD6=W <- V0=H4 JDT=N (9.4%, 80.0%)	
FD6=W <- HGH=H CRR=N (9.4%, 80.0%)	
FD6=W <- SPD=L LAT=H (9.4%, 80.0%)	
FD6=W <- HGH=L V0=H1 (9.4%, 80.0%)	
FD6=W <- HGH=L OPP=H (9.4%, 80.0%)	
FD6=W <- LAT=H OPP=H (11.3%, 83.3%)	
FD6=W <- SST=L OPP=H (11.3%, 83.3%)	
FD6=W <- V0=H4 CRR=H LAT=L (9.4%, 80.0%)	
FD6=W <- V0=H4 CRR=H JDT=N (9.4%, 80.0%)	
FD6=W <- V0=H4 LAT=L JDT=N (9.4%, 80.0%)	
FD6=W <- HGH=H JDT=H CRR=N (9.4%, 80.0%)	
FD6=W <- HGH=L V0=H1 LAT=H (9.4%, 80.0%)	
FD6=W <- HGH=L JHR=N LAT=H (9.4%, 80.0%)	
FD6=W <- V0=H1 LAT=H ORR=N (9.4%, 80.0%)	
FD6=W <- LAT=H SST=L OPP=H (9.4%, 100.0%)	St.3
FD6=W <- V0=H4 CRR=H LAT=L JDT=N (9.4%, 80.0%)	
Stable Situation	
FD6=S <- CPP=L SPD=L (9.4%, 80.0%)	
FD6=S <- CPP=L SST=H (9.4%, 80.0%)	
FD6=S <- CPP=L HGH=N (15.1%, 87.5%)	
FD6=S <- SPD=L OPP=L (11.3%, 83.3%)	
FD6=S <- SPD=L SST=H (9.4%, 80.0%)	
FD6=S <- SPD=L ORR=L (11.3%, 83.3%)	
FD6=S <- SPD=L LAT=N (11.3%, 83.3%)	
FD6=S <- SPD=L HGH=N (13.2%, 85.7%)	
FD6=S <- V0=H3 OPP=L (9.4%, 80.0%)	
FD6=S <- V0=H3 JDT=N (9.4%, 80.0%)	
FD6=S <- V0=H3 SPD=N (13.2%, 85.7%)	
FD6=S <- V0=H3 HGH=N (13.2%, 85.7%)	
FD6=S <- OPP=L JHR=N (9.4%, 80.0%)	
FD6=S <- OPP=L LND=L (13.2%, 100.0%)	
FD6=S <- OPP=L JDT=N (9.4%, 80.0%)	
FD6=S <- OPP=L CRR=N (9.4%, 80.0%)	
FD6=S <- OPP=L HGH=N (17.0%, 88.9%)	
FD6=S <- V0=H1 HGH=N (9.4%, 80.0%)	
FD6=S <- SST=H JHR=N (13.2%, 85.7%)	
FD6=S <- SST=H LND=L (9.4%, 80.0%)	
FD6=S <- SST=H HGH=N (13.2%, 85.7%)	
FD6=S <- JHR=N LAT=N (9.4%, 80.0%)	
FD6=S <- JHR=N SPD=N (11.3%, 83.3%)	
FD6=S <- JHR=N HGH=N (18.9%, 80.0%)	
FD6=S <- ORR=L LND=L (13.2%, 100.0%)	

FD6=S <- ORR=L HGH=N (18.9%, 80.0%)	
FD6=S <- SST=L OPP=N (9.4%, 80.0%)	
FD6=S <- SST=L CPP=N (9.4%, 80.0%)	
FD6=S <- LAT=H CPP=N (13.2%, 85.7%)	
FD6=S <- JDT=N CRR=N (15.1%, 87.5%)	
FD6=S <- CRR=N SPD=N (13.2%, 85.7%)	
FD6=S <- CPP=L JDT=L SST=H (9.4%, 80.0%)	
FD6=S <- CPP=L JDT=L JHR=N (9.4%, 100.0%)	
FD6=S <- CPP=L JDT=L HGH=N (11.3%, 83.3%)	
FD6=S <- CPP=L OPP=L LAT=N (9.4%, 80.0%)	
FD6=S <- CPP=L CRR=L ORR=L (9.4%, 80.0%)	
FD6=S <- CPP=L CRR=L HGH=N (9.4%, 80.0%)	
FD6=S <- CPP=L JHR=N LND=L (9.4%, 80.0%)	
FD6=S <- CPP=L JHR=N HGH=N (9.4%, 100.0%)	
FD6=S <- CPP=L ORR=L LND=L (9.4%, 100.0%)	
FD6=S <- CPP=L ORR=L LAT=N (9.4%, 80.0%)	
FD6=S <- CPP=L ORR=L HGH=N (9.4%, 80.0%)	
FD6=S <- CPP=L LND=L HGH=N (9.4%, 100.0%)	
FD6=S <- SPD=L JDT=L HGH=N (9.4%, 80.0%)	
FD6=S <- SPD=L OPP=L ORR=L (9.4%, 80.0%)	
FD6=S <- SPD=L JHR=N HGH=N (9.4%, 80.0%)	
FD6=S <- SPD=L ORR=L HGH=N (9.4%, 100.0%)	St.4
FD6=S <- SPD=L LND=L HGH=N (9.4%, 80.0%)	
FD6=S <- V0=H3 OPP=L SPD=N (9.4%, 80.0%)	
FD6=S <- V0=H3 LAT=H ORR=N (9.4%, 80.0%)	
FD6=S <- V0=H3 CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- V0=H3 SPD=N HGH=N (9.4%, 100.0%)	
FD6=S <- V0=H3 SPD=N ORR=N (9.4%, 100.0%)	
FD6=S <- V0=H3 HGH=N ORR=N (9.4%, 80.0%)	
FD6=S <- JDT=L SST=H JHR=N (11.3%, 100.0%)	
FD6=S <- JDT=L SST=H HGH=N (9.4%, 100.0%)	
FD6=S <- JDT=L JHR=N HGH=N (13.2%, 85.7%)	
FD6=S <- JDT=L LAT=N HGH=N (9.4%, 80.0%)	
FD6=S <- OPP=L JHR=H JDT=H (9.4%, 80.0%)	
FD6=S <- OPP=L ORR=L LND=L (11.3%, 100.0%)	
FD6=S <- OPP=L ORR=L HGH=N (13.2%, 85.7%)	
FD6=S <- OPP=L LND=L LAT=N (9.4%, 100.0%)	
FD6=S <- OPP=L LND=L HGH=N (9.4%, 100.0%)	
FD6=S <- OPP=L SST=L HGH=N (11.3%, 83.3%)	
FD6=S <- OPP=L SPD=N HGH=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LND=H (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L OPP=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L JHR=L (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L JDT=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H JDT=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H JHR=L (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H CPP=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N JHR=L (11.3%, 83.3%)	
FD6=S <- SPD=H OPP=N CPP=N (11.3%, 83.3%)	
FD6=S <- SPD=H OPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- SPD=H JHR=L CPP=N (11.3%, 83.3%)	
FD6=S <- SPD=H JHR=L CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H JDT=N CPP=N (9.4%, 80.0%)	
FD6=S <- SPD=H JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- CRR=L ORR=L LND=L (9.4%, 100.0%)	
FD6=S <- HGH=L SST=N LND=H (9.4%, 80.0%)	

FD6=S <- HGH=L SST=N JDT=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H JHR=L (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H CPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H OPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H CPP=N (11.3%, 83.3%)	
FD6=S <- HGH=L LND=H ORR=N (11.3%, 83.3%)	
FD6=S <- HGH=L OPP=N JHR=L (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L JHR=L ORR=N (11.3%, 83.3%)	
FD6=S <- HGH=L JDT=N CPP=N (11.3%, 83.3%)	
FD6=S <- HGH=L JDT=N CRR=N (11.3%, 83.3%)	
FD6=S <- HGH=L CPP=N CRR=N (11.3%, 83.3%)	
FD6=S <- HGH=L CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- SST=H JHR=N LND=L (9.4%, 80.0%)	
FD6=S <- SST=H JHR=N HGH=N (11.3%, 83.3%)	
FD6=S <- SST=H LAT=N OPP=H (9.4%, 80.0%)	
FD6=S <- SST=H LAT=N HGH=N (9.4%, 100.0%)	
FD6=S <- JHR=H ORR=L HGH=N (9.4%, 80.0%)	
FD6=S <- JHR=H SST=L SPD=N (9.4%, 80.0%)	
FD6=S <- JHR=H SPD=N HGH=N (11.3%, 83.3%)	
FD6=S <- JHR=N CRR=N HGH=N (11.3%, 83.3%)	
FD6=S <- ORR=L LND=L LAT=N (9.4%, 100.0%)	
FD6=S <- ORR=L LND=L HGH=N (11.3%, 100.0%)	
FD6=S <- ORR=L LAT=N HGH=N (9.4%, 80.0%)	
FD6=S <- LND=L LAT=N HGH=N (9.4%, 80.0%)	
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FD6=S <- SST=N JDT=N CPP=N (11.3%, 83.3%)	
FD6=S <- SST=N JDT=N CRR=N (9.4%, 100.0%)	
FD6=S <- SST=N JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H LND=H JHR=L (9.4%, 80.0%)	
FD6=S <- LAT=H LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H OPP=N CPP=N (9.4%, 80.0%)	
FD6=S <- LAT=H JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- LAT=H JHR=L CRR=N (9.4%, 80.0%)	
FD6=S <- LAT=H JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H JDT=N CRR=N (11.3%, 83.3%)	
FD6=S <- LAT=H JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H CPP=N CRR=N (11.3%, 83.3%)	
FD6=S <- LAT=H CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N JHR=L (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N CPP=N (11.3%, 83.3%)	
FD6=S <- LND=H OPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H JHR=L CPP=N (9.4%, 80.0%)	
FD6=S <- LND=H JHR=L CRR=N (9.4%, 80.0%)	
FD6=S <- LND=H JHR=L ORR=N (11.3%, 83.3%)	
FD6=S <- LND=H JDT=N CPP=N (13.2%, 85.7%)	
FD6=S <- LND=H JDT=N CRR=N (13.2%, 85.7%)	
FD6=S <- LND=H JDT=N ORR=N (11.3%, 83.3%)	
FD6=S <- LND=H CPP=N CRR=N (11.3%, 83.3%)	
FD6=S <- LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- OPP=N JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- OPP=N JHR=L CPP=N (11.3%, 83.3%)	
FD6=S <- OPP=N JHR=L CRR=N (9.4%, 80.0%)	
FD6=S <- OPP=N JDT=N CPP=N (11.3%, 83.3%)	
FD6=S <- JHR=L JDT=N ORR=N (11.3%, 83.3%)	
FD6=S <- JHR=L CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- JHR=L CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- JDT=N CPP=N CRR=N (11.3%, 100.0%)	
FD6=S <- JDT=N CPP=N ORR=N (9.4%, 100.0%)	

FD6=S <- JDT=N CRR=N ORR=N (9.4%, 100.0%)	
FD6=S <- JDT=N SPD=N HGH=N (9.4%, 80.0%)	
FD6=S <- CPP=N SPD=N HGH=N (9.4%, 80.0%)	
FD6=S <- CRR=N SPD=N HGH=N (9.4%, 100.0%)	
FD6=S <- SPD=N HGH=N ORR=N (11.3%, 83.3%)	
FD6=S <- CPP=L JDT=L JHR=N HGH=N (9.4%, 100.0%)	
FD6=S <- CPP=L OPP=L ORR=L LAT=N (9.4%, 80.0%)	
FD6=S <- SPD=L JDT=L JHR=N HGH=N (9.4%, 80.0%)	
FD6=S <- JDT=L SST=H JHR=N HGH=N (9.4%, 100.0%)	
FD6=S <- JDT=L JHR=N LND=L HGH=N (9.4%, 80.0%)	
FD6=S <- OPP=L JHR=H ORR=L JDT=H (9.4%, 80.0%)	
FD6=S <- OPP=L ORR=L LND=L LAT=N (9.4%, 100.0%)	
FD6=S <- OPP=L ORR=L LND=L HGH=N (9.4%, 100.0%)	
FD6=S <- OPP=L ORR=L SST=L HGH=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H LND=H (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H JDT=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LND=H CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L OPP=N JHR=L (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L OPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H LND=H CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H JHR=L CPP=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H JHR=L CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N JHR=L CPP=N (9.4%, 100.0%)	
FD6=S <- SPD=H OPP=N JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H JHR=L CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L SST=N LND=H JDT=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H LND=H JHR=L (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N CPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H JDT=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H OPP=N JDT=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H OPP=N CPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H JHR=L ORR=N (9.4%, 100.0%)	
FD6=S <- HGH=L LND=H JDT=N CPP=N (11.3%, 83.3%)	
FD6=S <- HGH=L LND=H JDT=N CRR=N (11.3%, 83.3%)	
FD6=S <- HGH=L LND=H JDT=N ORR=N (9.4%, 100.0%)	
FD6=S <- HGH=L LND=H CPP=N CRR=N (9.4%, 100.0%)	
FD6=S <- HGH=L LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N JDT=N CPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N CPP=N CRR=N (9.4%, 80.0%)	

FD6=S <- HGH=L OPP=N CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L OPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L JHR=L JDT=N ORR=N (9.4%, 100.0%)	
FD6=S <- HGH=L JDT=N CPP=N CRR=N (9.4%, 100.0%)	
FD6=S <- HGH=L CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- JHR=H SST=L SPD=N HGH=N (9.4%, 80.0%)	
FD6=S <- SST=N LND=H JDT=N CPP=N (9.4%, 80.0%)	
FD6=S <- LAT=H LND=H JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- LAT=H LND=H JDT=N CRR=N (11.3%, 83.3%)	
FD6=S <- LAT=H LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H OPP=N CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- LAT=H OPP=N CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H JHR=L CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N JDT=N CPP=N (11.3%, 83.3%)	
FD6=S <- LND=H OPP=N JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H JHR=L JDT=N ORR=N (11.3%, 83.3%)	
FD6=S <- LND=H JHR=L CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- LND=H JDT=N CPP=N CRR=N (9.4%, 100.0%)	
FD6=S <- OPP=N JHR=L JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- OPP=N JHR=L CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- JDT=N CPP=N CRR=N ORR=N (9.4%, 100.0%)	
FD6=S <- SPD=H HGH=L LAT=H LND=H CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H LND=H ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L OPP=N JHR=L ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LAT=H LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H LND=H JHR=L CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- SPD=H OPP=N CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H LND=H JHR=L JDT=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H LND=H JDT=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H LND=H CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N CPP=N CRR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N CPP=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H OPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LAT=H CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H OPP=N JDT=N CPP=N (9.4%, 80.0%)	
FD6=S <- HGH=L LND=H JHR=L JDT=N ORR=N (9.4%, 100.0%)	
FD6=S <- HGH=L LND=H JDT=N CPP=N CRR=N (9.4%, 100.0%)	
FD6=S <- HGH=L OPP=N CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- LAT=H OPP=N CPP=N CRR=N ORR=N (9.4%, 80.0%)	
FD6=S <- LND=H OPP=N JHR=L JDT=N ORR=N (9.4%, 80.0%)	
FD6=S <- SPD=H HGH=L LAT=H LND=H CRR=N ORR=N (9.4%, 80.0%)	St.5
FD6=S <- HGH=L LAT=H OPP=N CPP=N CRR=N ORR=N (9.4%, 80.0%)	