Cartopy and Tephi: Open source Python packages for visualising geospatial and thermodynamic data.

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In a nutshell ...

Cartopy is an open source Python package for advanced map generation with an intuitive matplotlib interface.

• Has been seamlessly integrated with matplotlib and exposes a custom *GeoAxes*.
• Leverages the combined capability of PROJ.4 and the Shapely Python package.
• Encapsulates projection definitions within object oriented coordinate reference systems.
• Can generate new coordinate reference systems at runtime using EPSG codes.
• Easily transforms point, line, polygon and raster images between projections.
• Provides an integrated ESRI Shapefile reader and Natural Earth features interface.
• Supports pan and zoom WMS and WMTS web mapping services.
• Includes OpenStreetMap, MapQuest, Mapbox and Google tiling.

Web Map Services ...
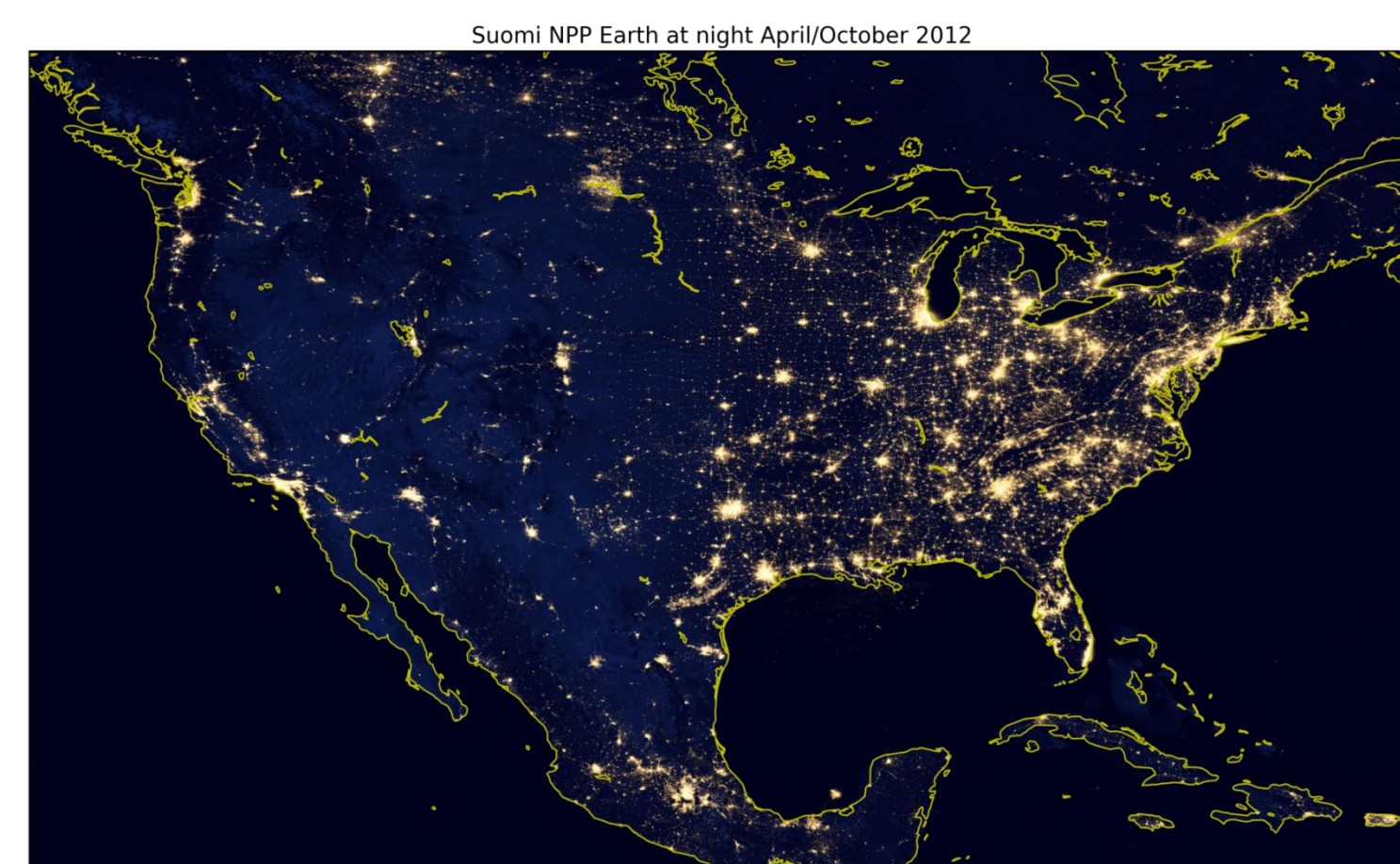
Cartopy uses the OGC web services library (OWSLib) to support interactive pan and zoom WMS and WMTS slippy maps.

This first example WMTS layer is a single composite of data sampled over nine days in April 2012 and thirteen days in October 2012 showing the Earth at night[1]. It does not vary over time. The imagery was collected by the Suomi National Polar-orbiting Partnership (Suomi NPP) weather satellite operated by the United States National Oceanic and Atmospheric Administration (NOAA).
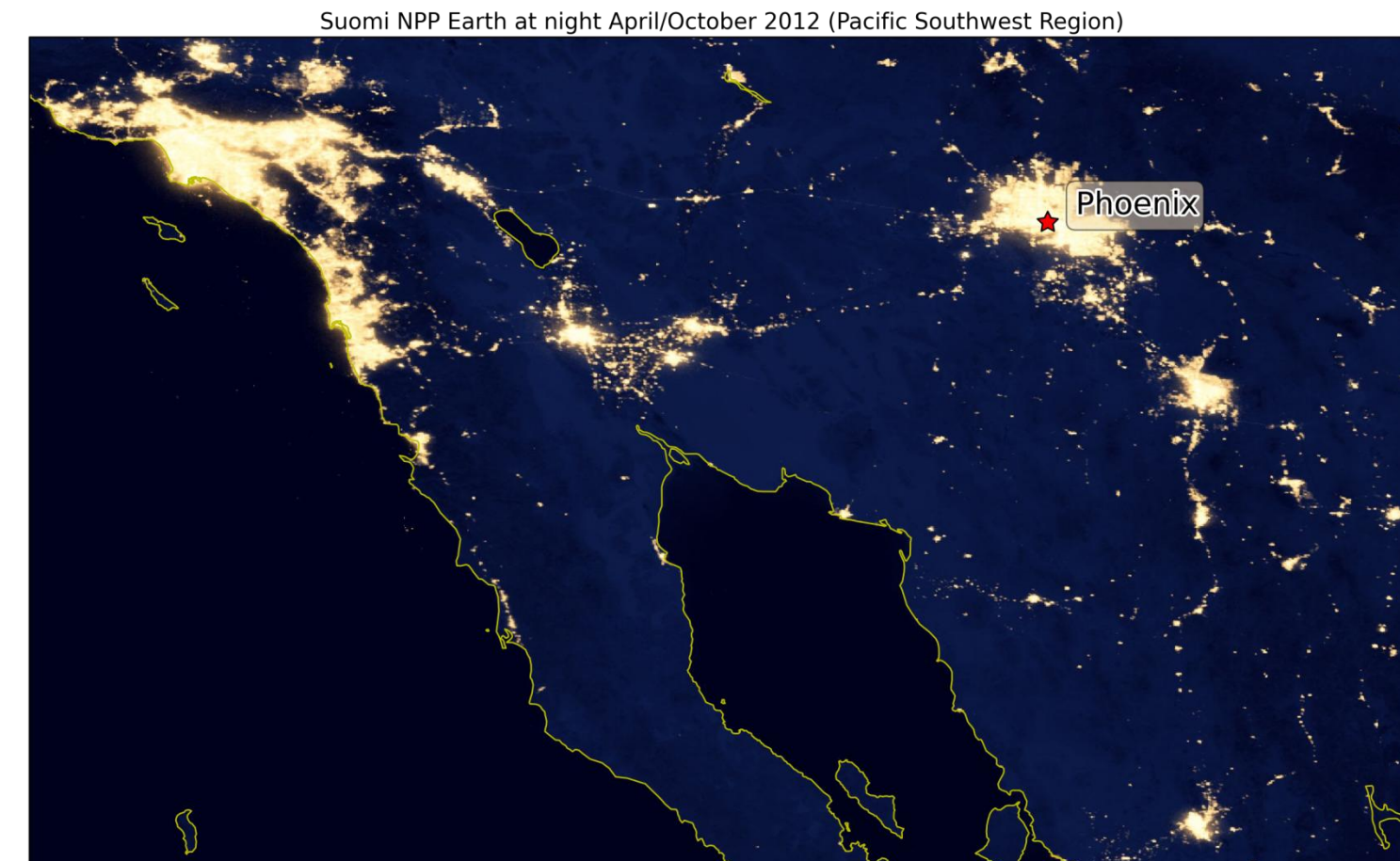
The next example shows temperature imagery of a WMS raster layer hosted by NOAA[2] in its native projection. Cartopy is not limited to the native projection of the imagery provided by a WMS service. Rather, it is able to re-project the data at runtime to any target projection. In this case, an Orthographic projection with a central longitude of 102.5°W.
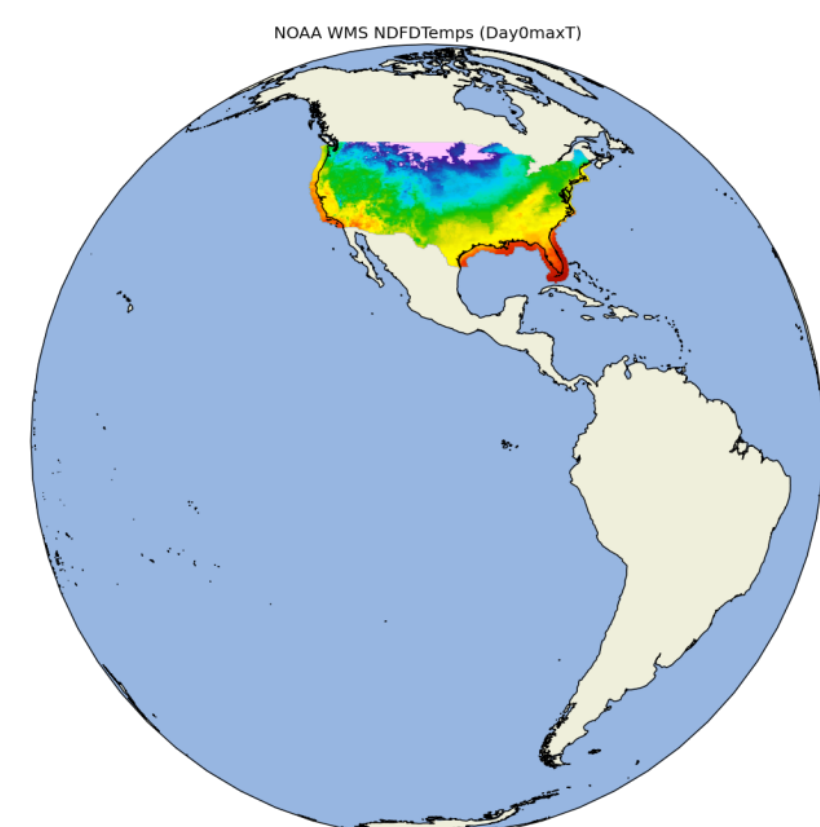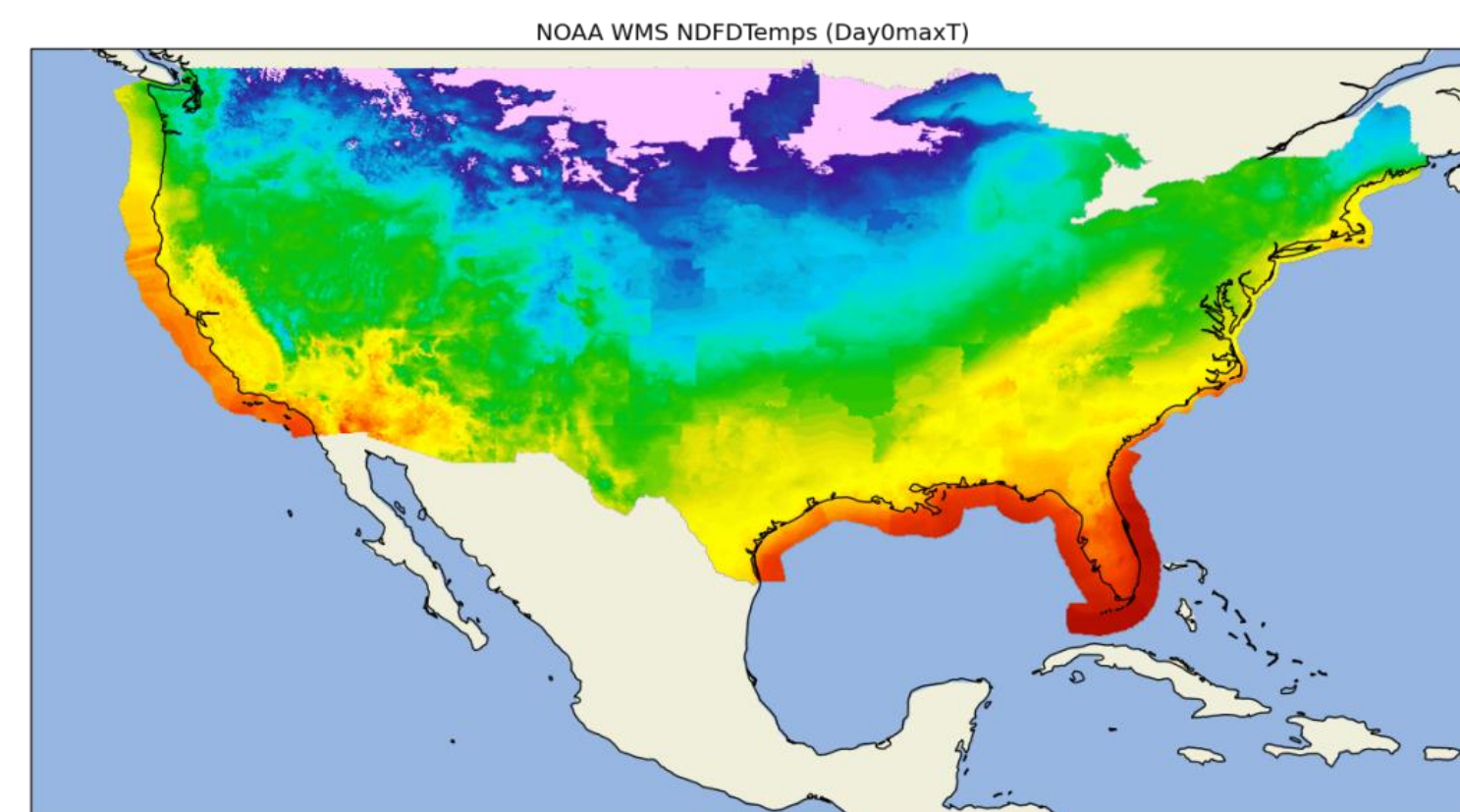
Map tiling ...

Cartopy supports quiver and stream plotting for any projection. This example plots a snapshot of hurricane Haiyan, also known as Typhoon Yolanda in the Philippines. This was a category 5 super typhoon active from 2 November to 11 November 2013. The NetCDF MERRA reanalysis northward and eastward wind data at 10m above the displacement height was sourced from NASA GES DISC[3]. The Iris open source Python package was used to load and manipulate the data.

The first Cartopy quiver plot has a base layer of MapQuest Open Aerial tiles, whereas the expanded inset shows a Cartopy stream plot with a base layer of OpenStreetMap tiles.
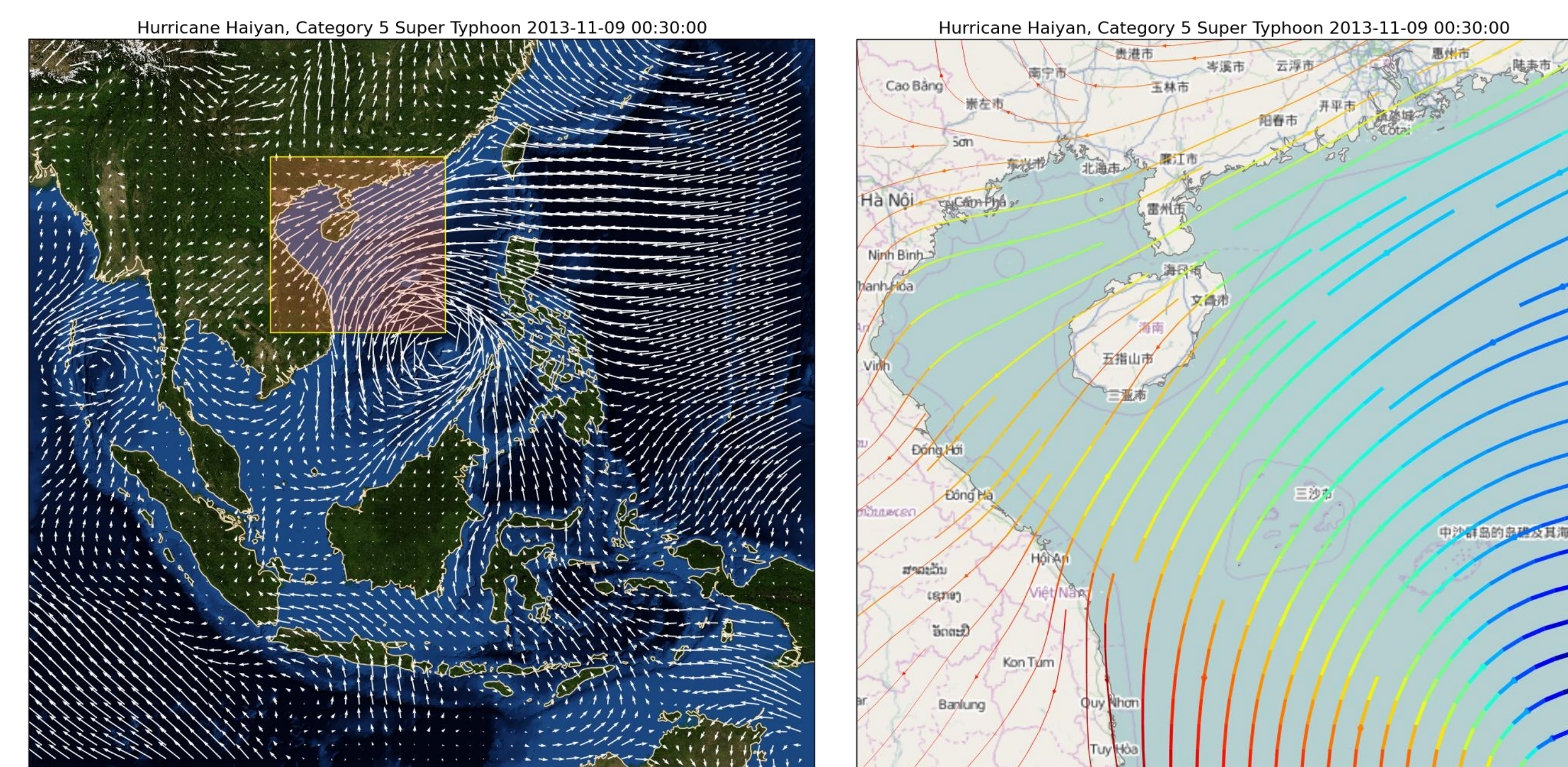
Natural Earth features and shapely geometries ...

The Cartopy shape reader provides a simple interface to the metadata and vector payload of an ESRI Shapefile. The vector payload is exposed as Shapely geometries, which can be easily projected by Cartopy and manipulated using standard Shapely predicates and operations.

Cartopy also provides a convenient feature interface to download and cache free vector and raster map data from *Natural Earth* at 1:10m, 1:50m and 1:110 million scales.
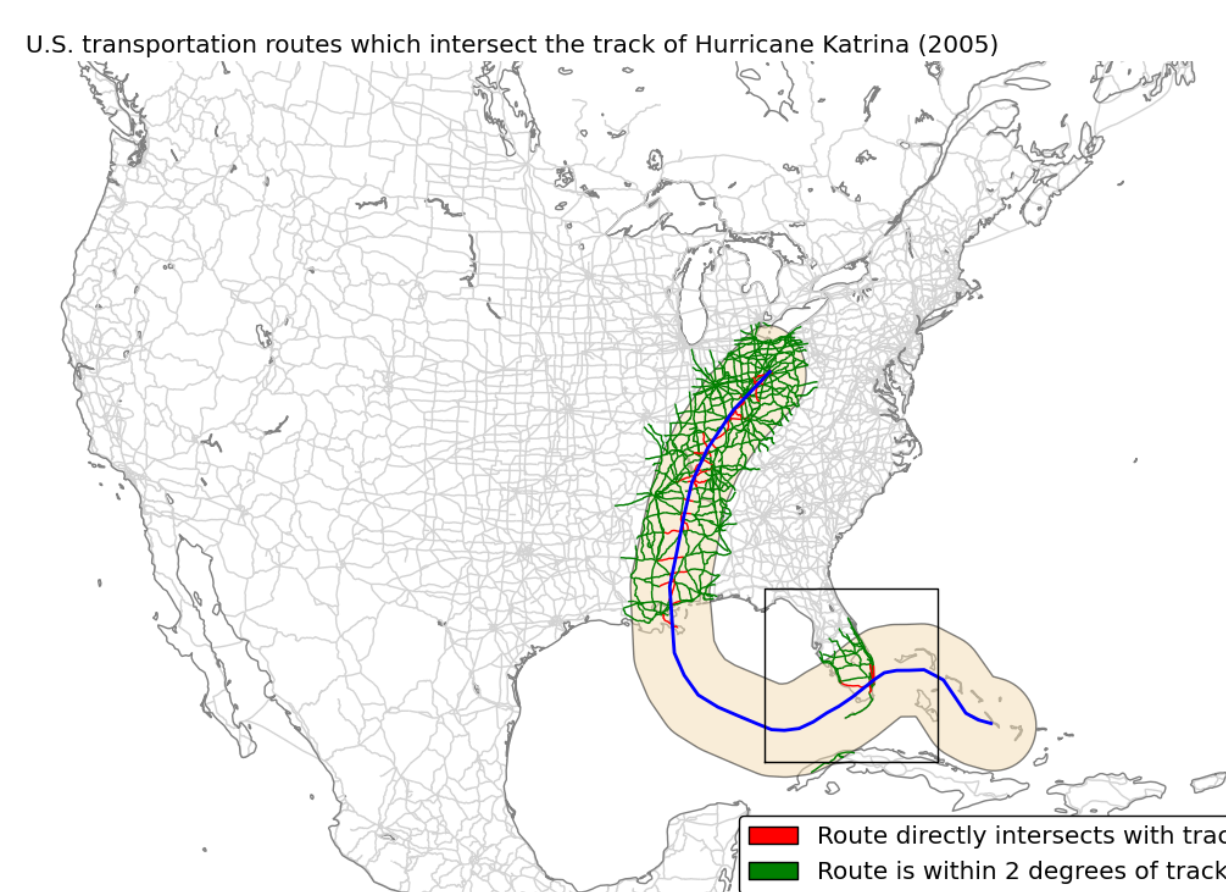
This simple example highlights the combined power of Cartopy and Shapely. The Cartopy shape reader downloads global transportation routes from Natural Earth. The Shapely geometry of each route is used to determine whether it intersects with the Shapely geometry track of hurricane Katrina. The resulting plot is rendered by Cartopy in a North American Lambert Conformal Conic projection.

In a nutshell ...

Tephi is a lightweight open source Python package building upon NumPy and matplotlib to provide pan and zoom tephigram plotting.

• Represents a tephigram within a custom matplotlib *TephiAxes*, with fixed aspect ratio isotherms and dry adiabats.
• Provides full control and customisation of all isopleths and associated text labels using the standard matplotlib API.
• Uses matplotlib locators to easily control the placement of isotherms, isobars, humidity mixing ratios and dry/wet adiabats.
• Allows wind barb observations to be easily associated with an individual ascent profile.
• Enables the vertical wind shear through the atmosphere to be visualised with an inset hodograph.
• Has been adopted within the Met Office to deliver local area model UKV 1.5km forecast tephigrams.
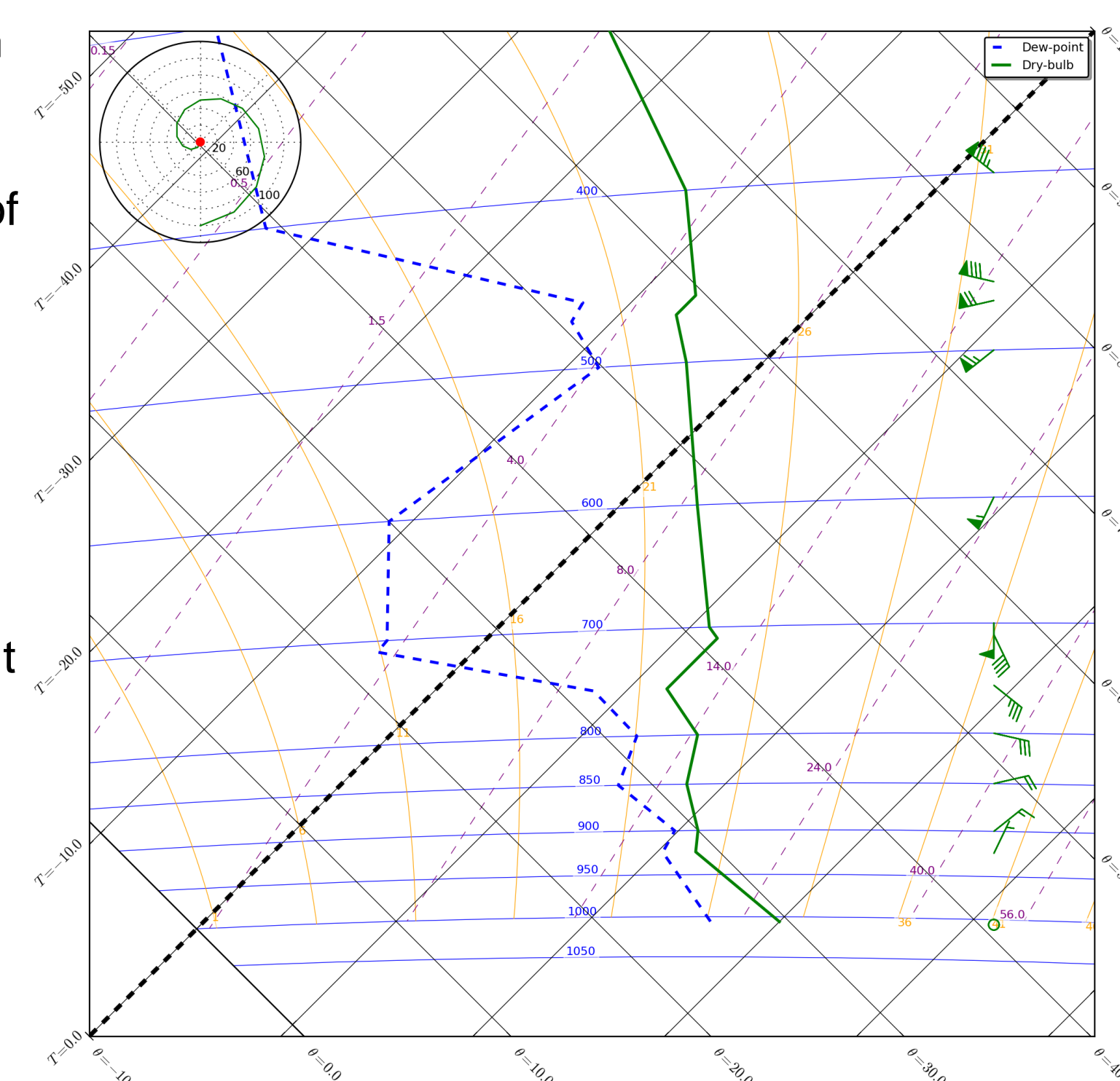
Tephigram analysis tools ...
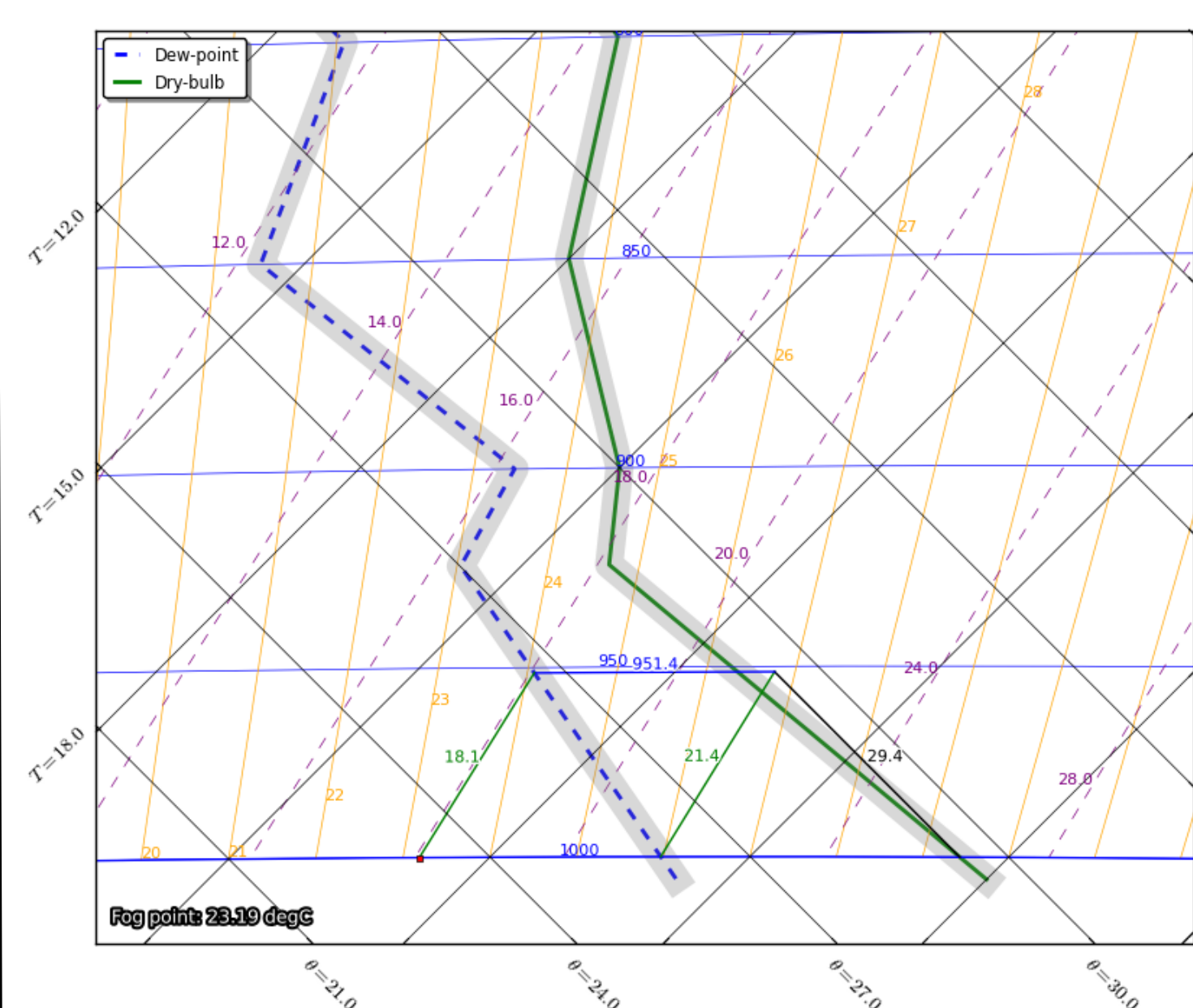
Future work will focus on extending the capability of Tephi by providing a suite of tools that allow forecasters to easily perform standard tephigram analysis.

This example uses a Normand's Point construction to forecast the temperature at which radiation fog could form given the selected dew-point and dry-bulb profiles.

Links
• http://scitools.org.uk
• http://stackoverflow.com/questions/tagged/cartopy
• https://github.com/SciTools
• https://github.com/bjlittle/ams2015

Data References
1. http://map1c.vis.earthdata.nasa.gov/wmts-geo/wmts.cgi
2. http://gis.srh.noaa.gov/arcgis/services/NDFDTemps/MapServer/WMSServer
3. http://goldsmr2.sci.gsfc.nasa.gov/opendap/MERRA/MAT1NXSLV.5.2.0/2013/11/contents.html

http://goo.gl/BJglOs   http://goo.gl/Q9TRB2   http://goo.gl/6fRhkv   http://goo.gl/oundn9