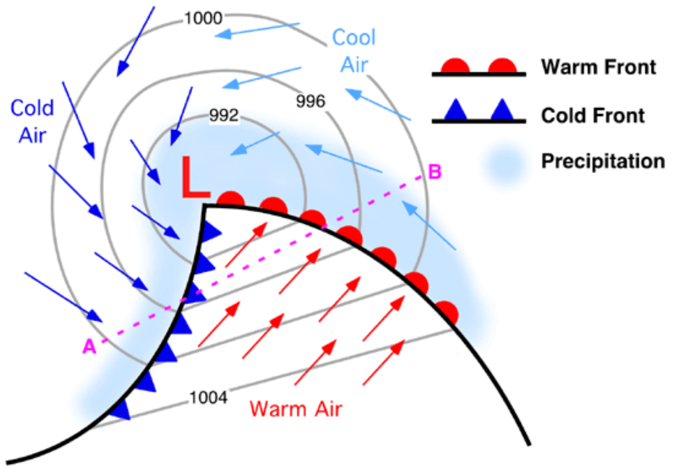
JBA Trust www.jbatrust.org

Challenge title: *Identification of Coherent Weather Features in Three Dimensions*

Two-dimensional weather charts are a common tool which allow us to quickly assess the current or predict future weather (e.g. where and when rain will fall).



http://www.physicalgeography.net

While weather features have long been subjectively hand-analysed on weather charts, recently there has been a push to use computer algorithms to objectively identify the location of weather features in two dimensions.

The use of computer algorithms to objectively identify weather features in global atmospheric reanalysis datasets (i.e. three-dimensional representations of the atmosphere produced using numerical weather prediction models and global climate models) allows the long-term climatology of weather features to be assessed for the first time.

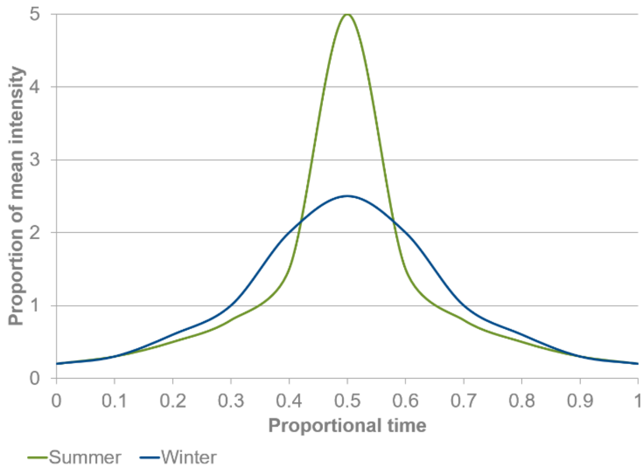
The identification of weather features, including African Easterly Waves and Atmospheric Rivers, in *three* dimensions is important for both understanding the atmospheric processes occurring and predicting how the atmosphere may evolve.

<u>The challenge</u>: Develop a generic computer-based tool or algorithm to identify coherent three dimensional weather structures, including a way of associating properties describing the shape and orientation of the structure. Then, test the methodology on the more complex problem of three-dimensional weather features, such as African easterly waves and atmospheric rivers, using atmospheric datasets.

Environment Agency

Challenge title: *Spatial rainfall distribution in flood modelling*

Most flood models assume uniform rainfall and hydrology over space and time. However, this is unrealistic – rain falls unevenly across a catchment and through time. Consequently, these models may over-estimate or under-estimate flood risk, leading to the construction of inadequate flood defences and drainage systems.



This may have environmental, humanitarian and economic consequences. Methods exist that can overcome this; for example, Monte Carlo analysis (requiring hundreds of thousands of model runs) and continuous simulation (requiring at least 100 years of data to be simulated at 5-15 minute time steps). However, these are labour-intensive and costly.

<u>The challenge</u>: Identify an approach that gets some of the benefits of a more detailed approach, with only a minimal increase in modelling.

Met Office

Challenge title: *Validating Convective-Scale Rainfall Forecasts and Estimating their Uncertainty.*

Weather forecasting centres are increasingly making use of high-resolution numerical weather prediction models, which cover a local domain of interest (e.g. the UK). These models are capable of simulating convective showers and thunderstorms, the dynamics of which occur on relatively small scales. Therefore, they are a vital tool for forecasting high-impact, heavy-rainfall events.

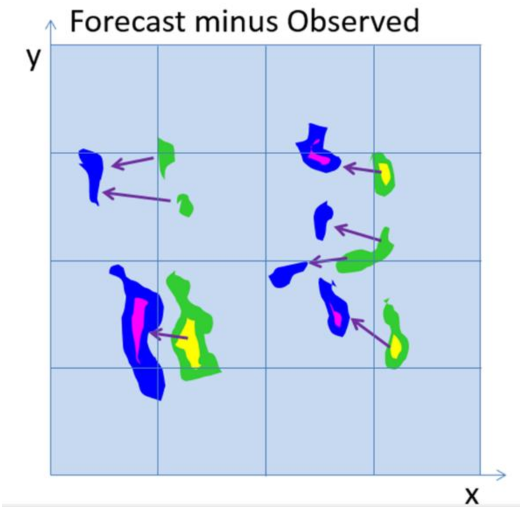
The forecasting of weather events, including the likely range of rainfall patterns, is achieved by estimating current atmospheric conditions and using model simulations to estimate how these conditions will change over time. By perturbing the initial starting conditions, we can generate a number of different predicted weather conditions, known collectively as an ensemble forecast. A more detailed explanation of ensemble forecasting can be found here.

The number of ensembles is restricted by the computational resources available, such that the ensemble size may not be sufficient to estimate accurate probabilities for the chance of rainfall at a given location.

A crucial element of model performance to assess is the skill of the model in predicting the location and timing of intense convective showers and thunderstorms. At a given time, the true spatial pattern of rainfall intensity can be estimated from radar observations, and this pattern can be compared with the rainfall predicted by the forecast model.

When the forecast areas of rain do not match these observations, there is *spatial displacement* between the locations of observed rainfall and forecast rainfall. There may also be error in the predicted intensity of rainfall.

This figure shows this spatial displacement between forecast rainfall (green) and observed rainfall (blue). The arrows show the displacement we wish to estimate.



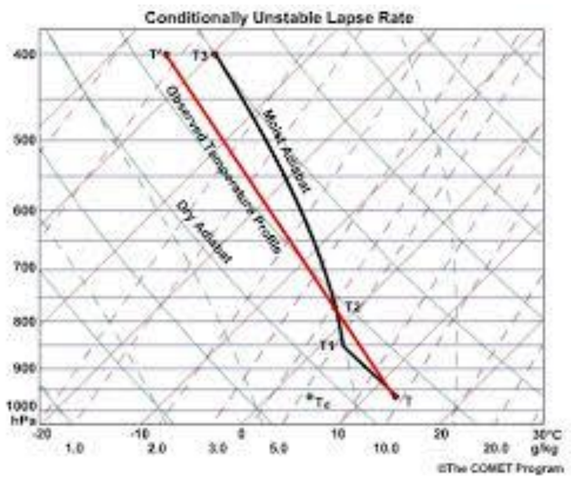
The challenge: How do we efficiently calculate this displacement metric?

Met Office

Challenge title: *Adjustment of a Column of Convectively Unstable Moist Air*

Rising air expands and cools due to the decrease in air pressure as altitude increases. When parcels of moist air rise, they cool and eventually reach a point where their water vapour content starts to exceed the saturation value for that height (or pressure level). At this point, the water vapour condenses, releasing latent heat which increases the temperature of the parcel. This boosts buoyancy of the parcel relative to the environment and it rises further. The opposite is true of descending air – as atmospheric pressure increases, the temperature of descending air increases as it is compressed.

Adiabatic heating and adiabatic cooling are terms used to describe this temperature change with varying altitude and pressure. Moist air contains more water vapour than dry air, so more latent heat is released into the parcel of moist air as it rises. Therefore, moist air cools at a lower rate with vertical movement than dry air.



Air parcels with highest potential temperature rise to the top of an atmospheric column, ensuring that the potential temperature increasing at all times. Without the effects of moisture, potential temperature is conserved in time and rises monotonically.

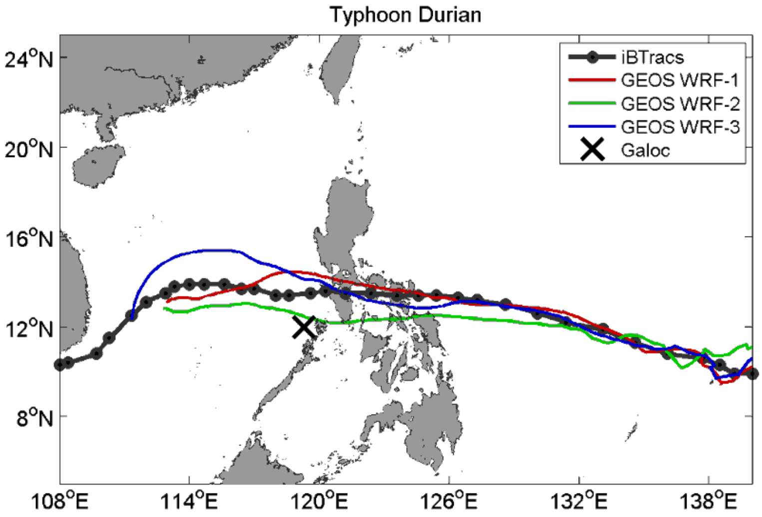
<u>The challenge</u>: What happens when moisture effects are included?

Fugro GEOS

Challenge title: *Statistical Framework for Utilisation of Modelled Data for Tropical Cyclones*

Fugro GEOS are increasingly asked to undertake risk analysis for offshore sites. This includes producing wind and wave design criteria for tropical cyclones in regions where such events occur relatively infrequently, such as East and West Africa, North West Australia and East Africa.

It is currently possible to model previously occurring individual storms multiple times and use these models to predict, for example, wave heights during a predicted cyclone (ensemble forecasting). This approach can generate a large enough datasets from which to estimate extremes. However, getting both the storm track and intensity to match historical data is a challenge.



<u>The challenge</u>: What is the statistical validity of the current approach? Is there a rigorous way of deciding how many ensembles to run for an individual storm in order to produce statistically valid extreme values?