JBA trust

Identification of coherent weather features in three dimensions

Environmental Modelling in Industry – Study Group

Rob Lamb & Kay Shelton

21st - 24th September 2015

JBA Trust - the basics...

‘developing knowledge and skills for environmental risks and resources management’

- Set up in 2011
- Funded by JBA Group but legally independent of JBA Group
- Majority external Board of Directors

Rob Lamb MA PhD
Managing Director
Rob has 20 years' experience in academic and commercial research and development. He specialises in hydrology anc flood risk science, has published work in numerous journals and is co-author of two text books. Since 2008, Rob has been Chief Scientist to the JBA Group, leading JBA's scientific research and development. In 2013 Rob was made an Honorary Professor at Lancaster University.

Jim Hall FREng
Chair of the Board of Trustees
Jim is Professor of Climate and Environmental Risks and Director of the Environmental Change Institute at the University of Oxford. His research focuses upon management of climate-related risks in infrastructure systems, in particular relating to flooding, coastal erosion and water scarcity.

Keith Beven
Keith is Distinguished Professor of Hydrology at Lancaster University, with research interests in risk and uncertainty in environmental modelling, particularly in the areas of rainfall runoff modelling, flood inundation, flood forecasting, hydrological change, and water quality modelling.

Jeremy Benn FREng
Jeremy is a Director of the Trust and CEO of the JBA Group. He has 30 years' experience of water engineering and hydrology gained from consultancy work in the UK, Ireland, Sri Lanka, Eastern Europe and Australia.

Nick Russell ACIB
Nick is a Director of the Trust. Having gained almost 40 years' experience in corporate banking he is now an independent financial consultant.

What we do

Research

- Foster links with UK universities and R&D organisations
- Publish research and data
- Share knowledge and good practice

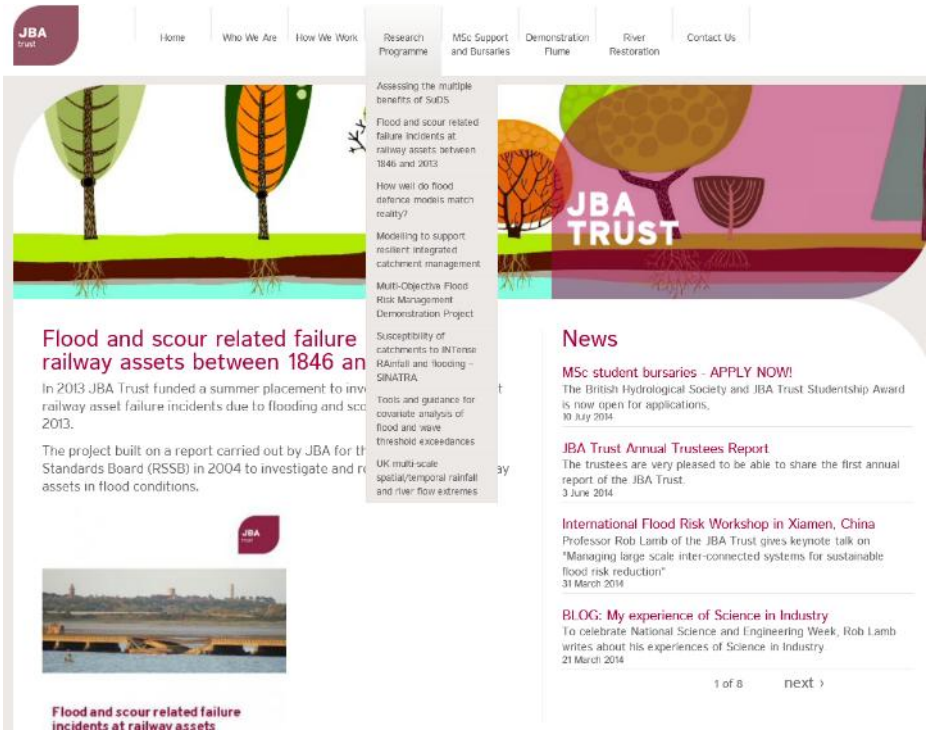
Events

- Training events and practical demonstrations (hydraulic flumes, wave tanks)
- Science fairs, public events
- Conference sponsorship

Support for students

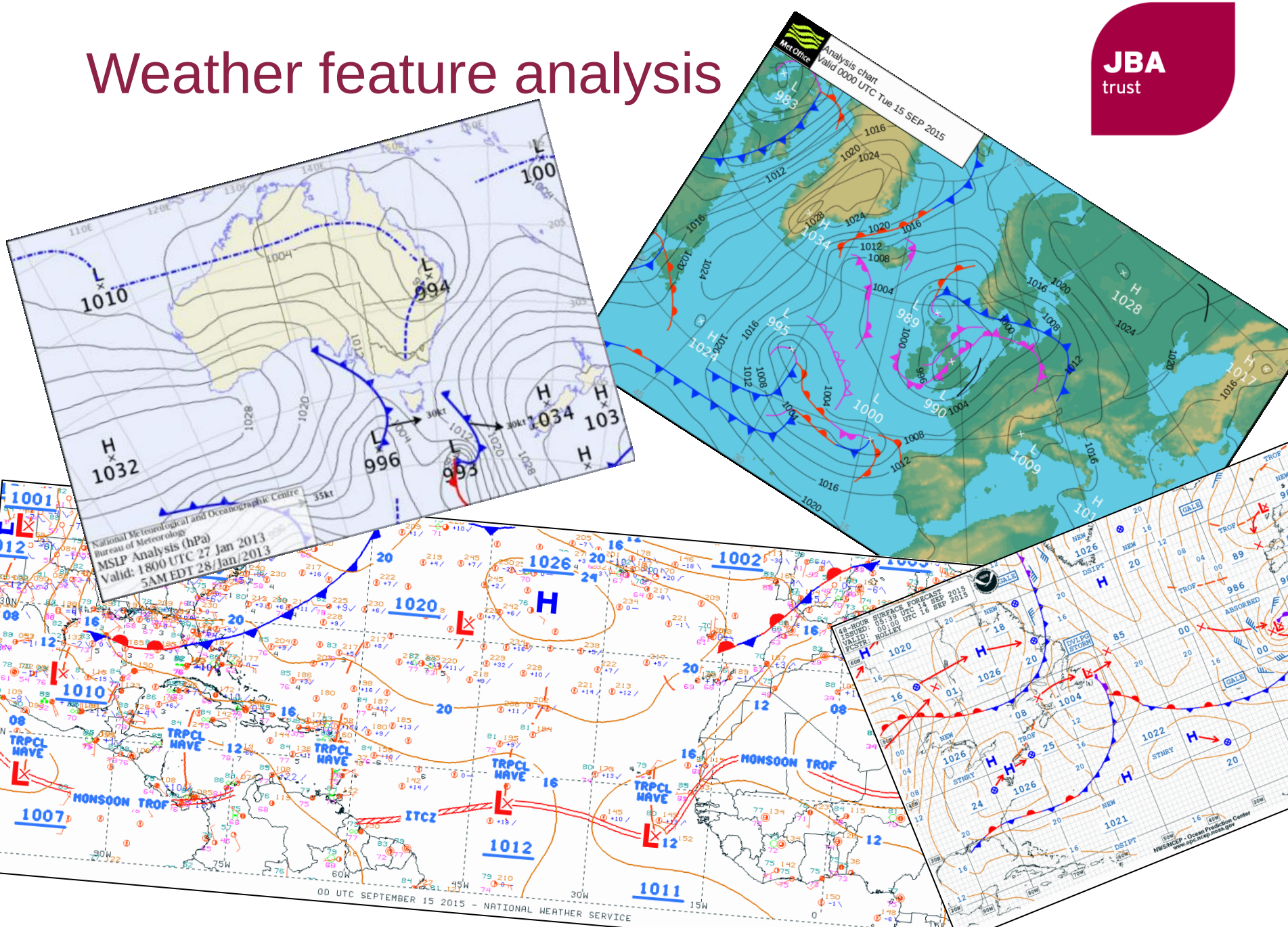
- Financial support for MSc and PhD students
- MSc placements in JBA
- Access to data and guidance

Find out more



www.jbatrust.org

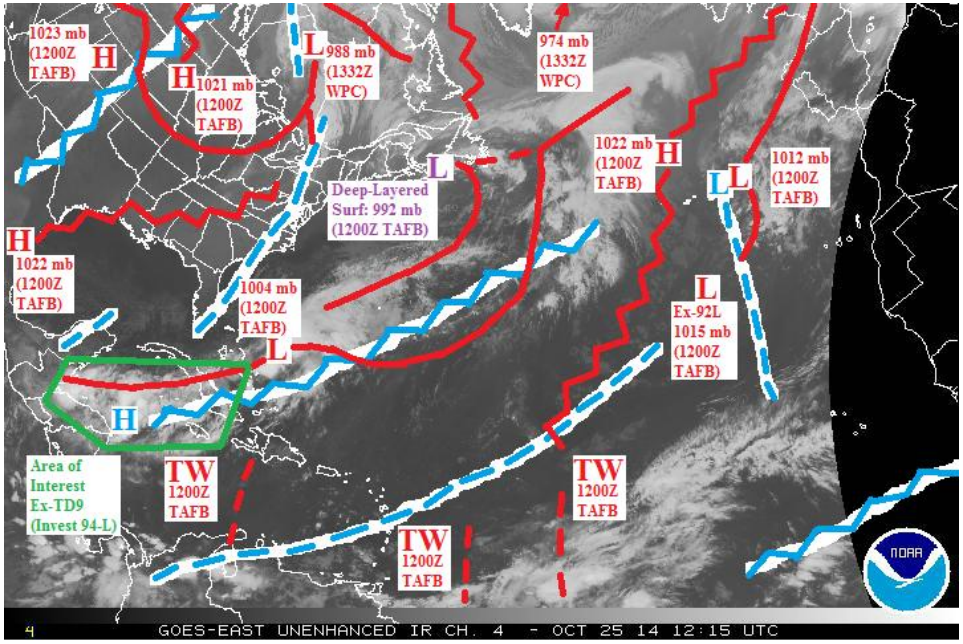
Weather feature analysis



Weather feature analysis

Quickly and easily provides a wealth of information to both forecasters and general public.

- Often manually analysed by forecasters
- Subjective and artful, experienced forecasters can add value
- Routine manual analysis still a primary tool used by forecasters in operational centres around the world.



Objective front depiction

- Work to identify and draw objective fronts operationally progressing since 1960s (Renard and Clarke, 1965). But still not routine.

- Often not used for research purposes – errors and inconsistencies are important.

- Recent push by UK Met Office to produce objectively identified fronts and cyclones using calculations and graphical masking (Hewson, 1997, 1998).

- Similar, augmented, technique applied to easterly waves (Berry et al., 2007).

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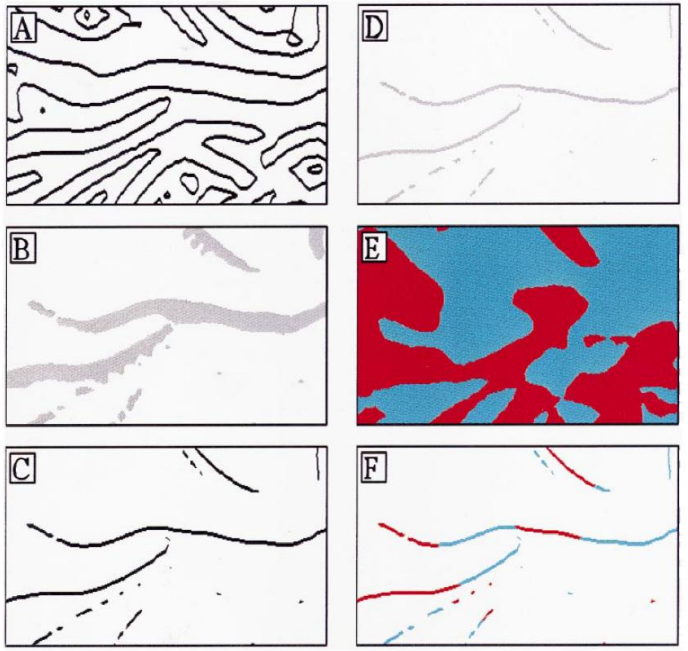
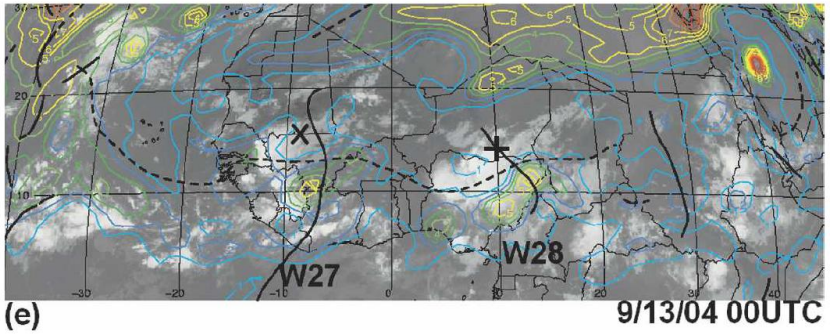


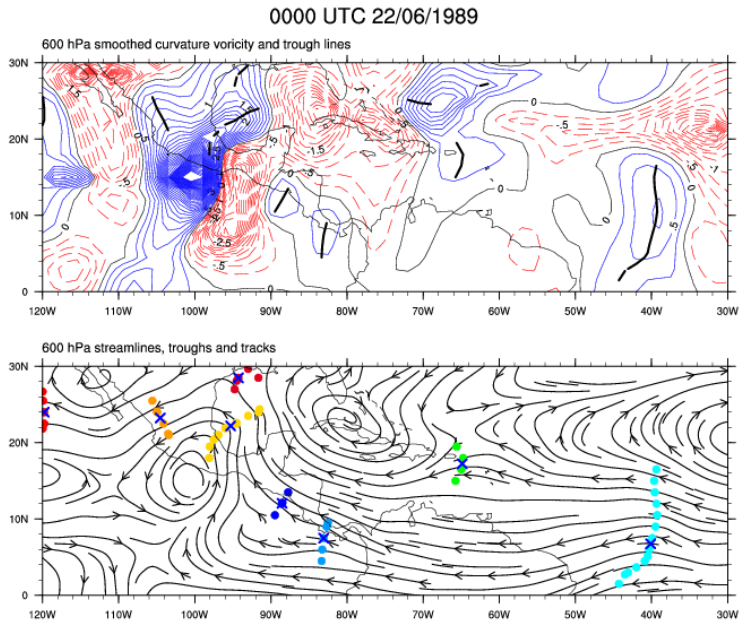
Hewson (1998)



Berry et al. (2007)

Feature identification in 2D (i)

- My PhD built on Hewson and Berry et al. technique, to devise method to numerically define easterly wave axes as a series of continuous points.
- Allowed for waves to be numerically tracked, composited and statistically analysed.
- Paved the way for the global climatology of fronts (Berry et al., 2011).



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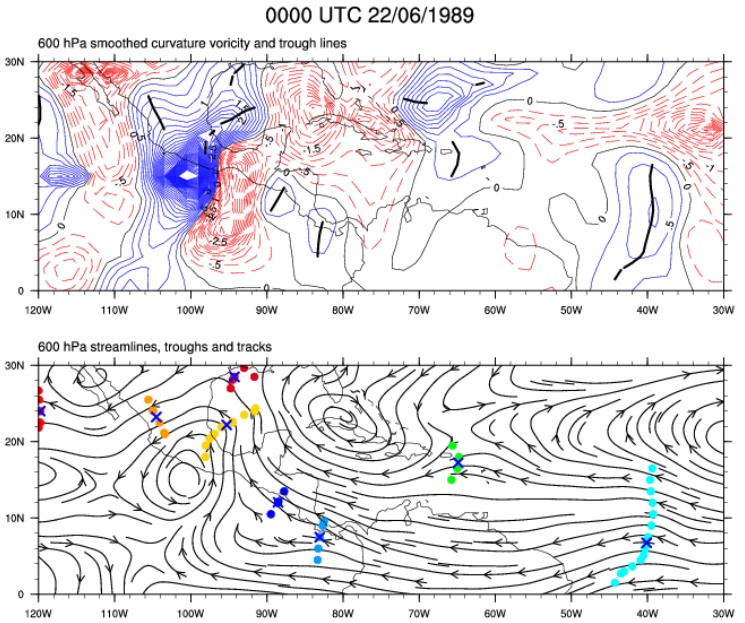
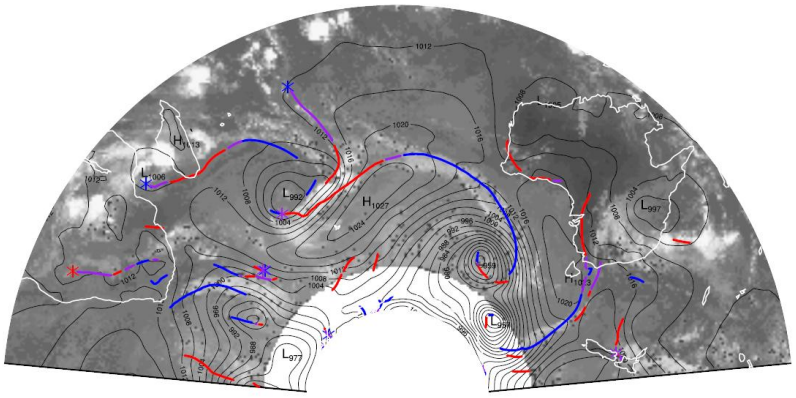
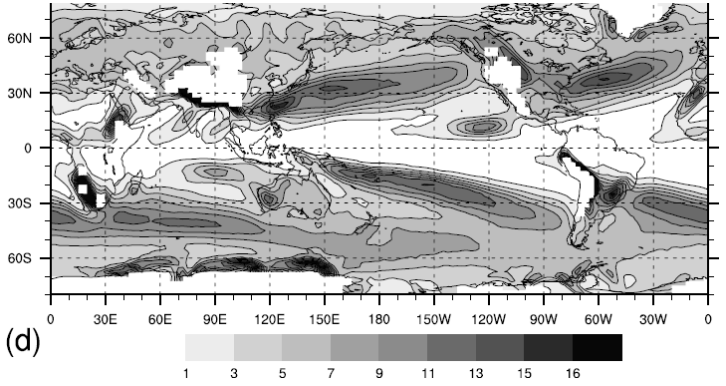


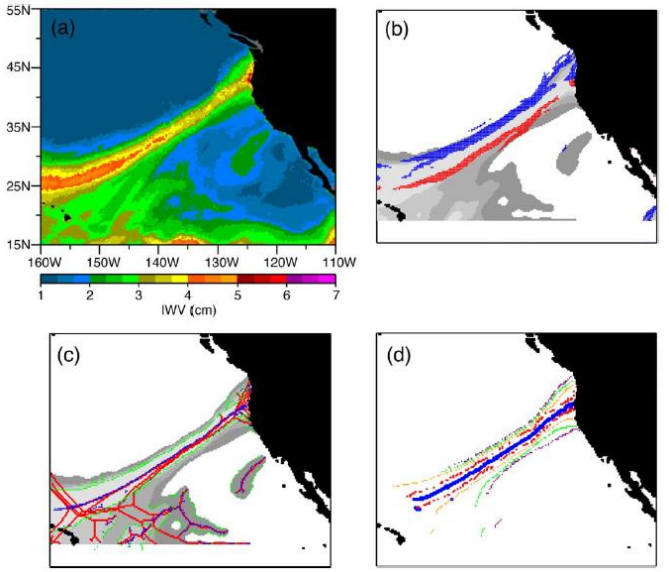




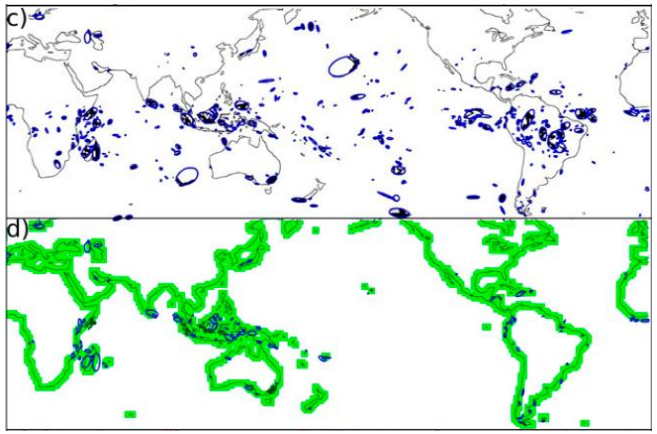
Berry et al. (2011)

Feature identification in 2D (ii)

- Extratropical, tropical cyclone and other vorticity or pressure maxima/minima (Hodges 1995; reviewed by Tory et al. 2012)
- Markov random field statistical model for locating the ITCZ in the eastern Pacific (Bain et al., 2011).
- Image processing technique used in identification of atmospheric rivers (Wick et al. 2013).
- Pattern recognition for coastally orientated rainfall signatures (Bergemann et al., 2015).
- ……and others……



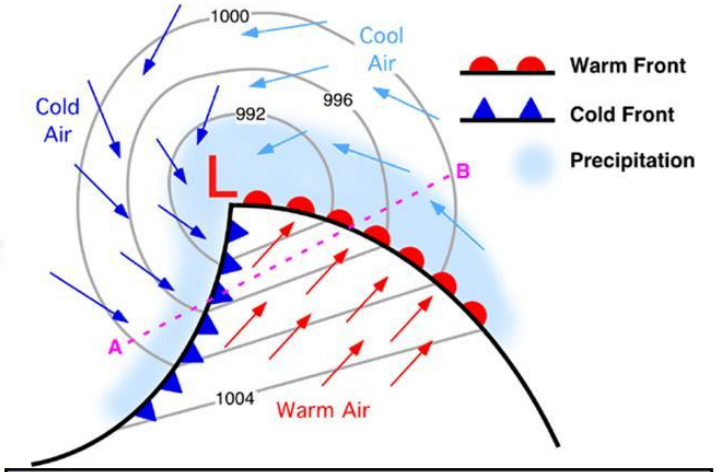
Wick et al. (2013)



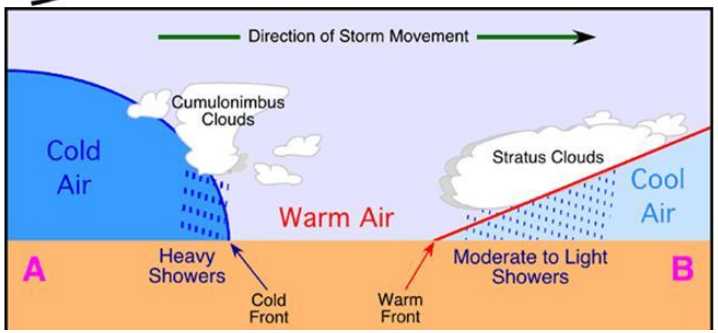
Bergemann et al. (2015)

Weather is three-dimensional! (i)

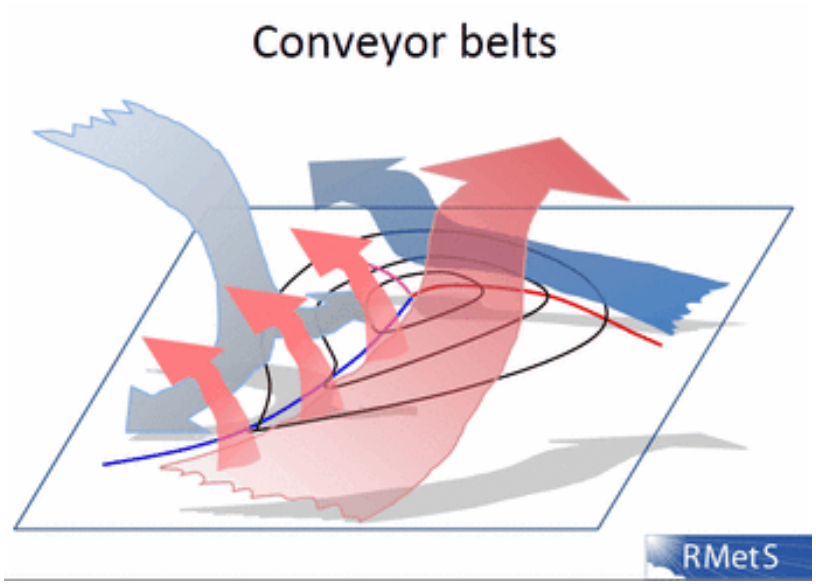
TOP VIEW



SIDE VIEW



PhysicalGeography.net



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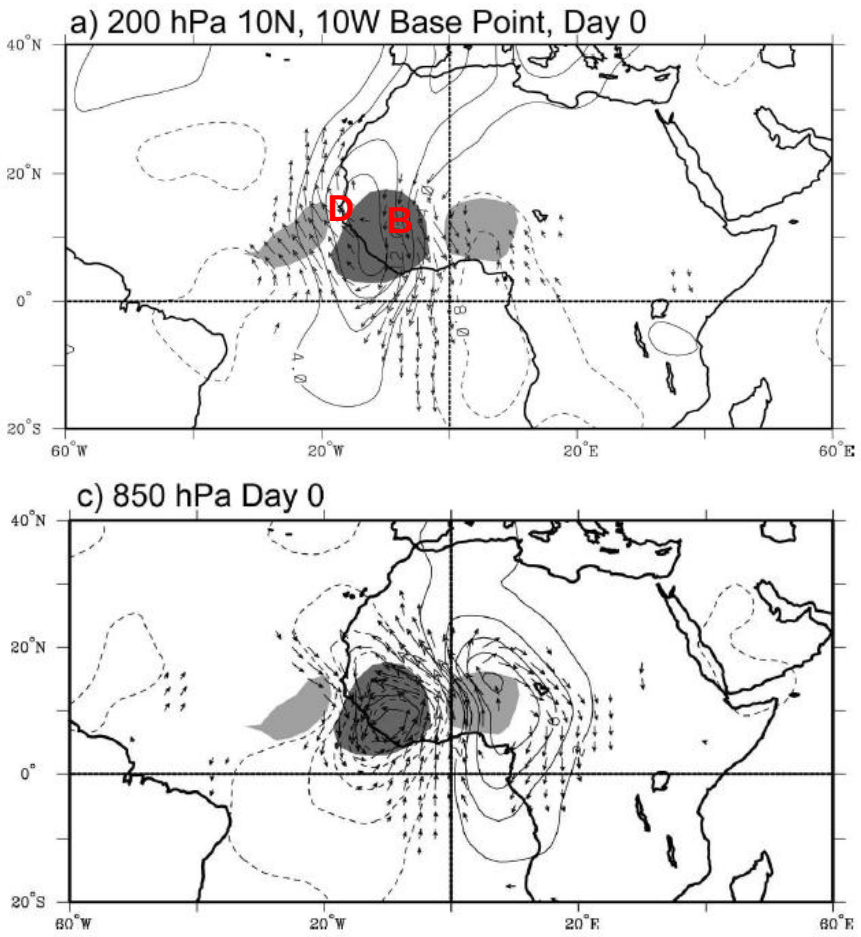
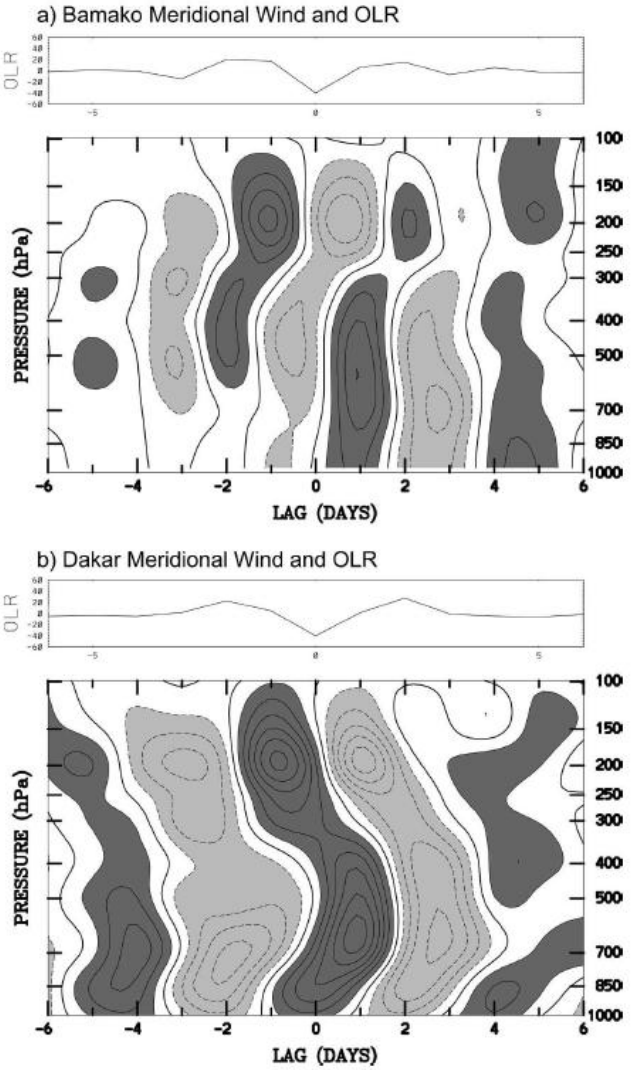
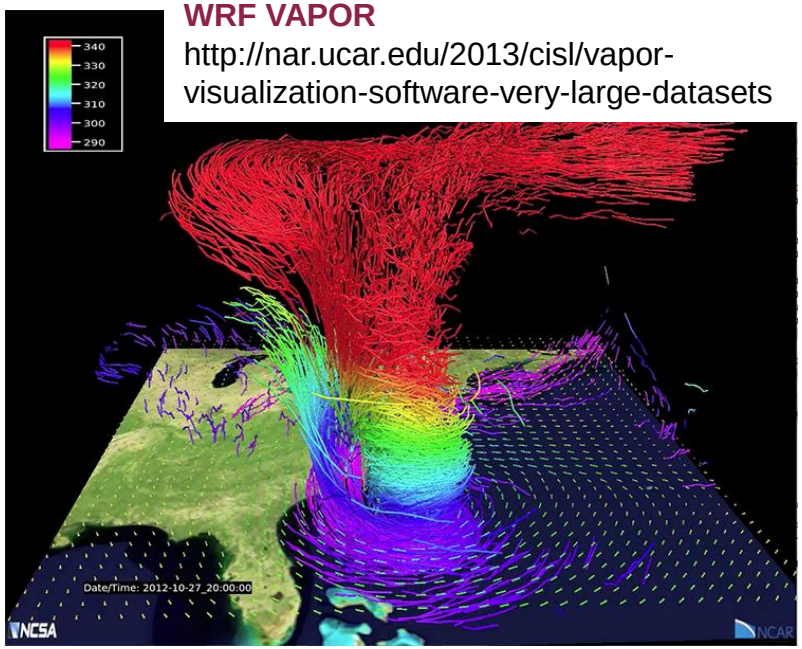


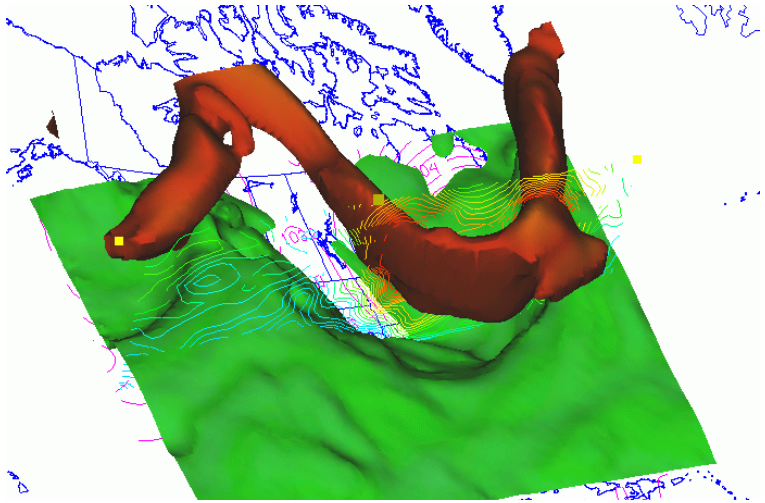


Kiladis et al. 2006

3D visualisation of weather (i)

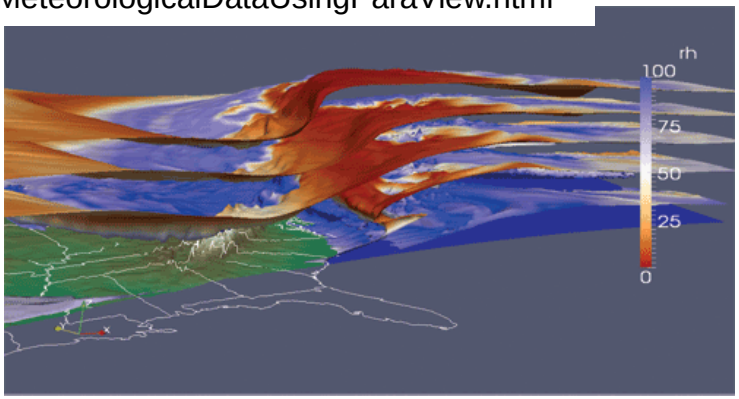
WRF VAPOR
http://nar.ucar.edu/2013/cisl/vapor-visualization-software-very-large-datasets

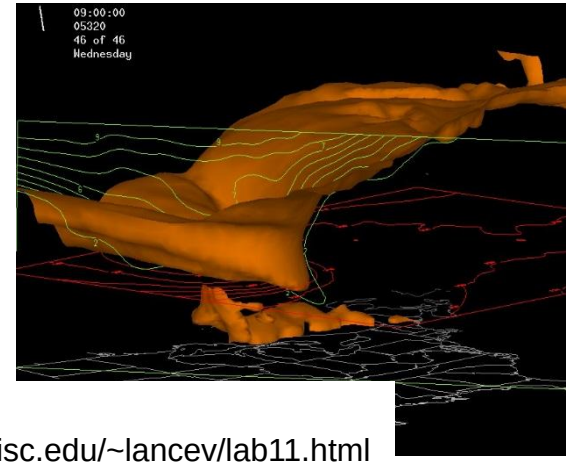




IDV
http://www.unidata.ucar.edu/software/idv/gallery/jetStream.gif

ParaView
http://www.kitware.com/media/html/DesktopVisualizationOfMeteorologicalDataUsingParaView.html





Vis5d
http://aos.wisc.edu/~lancev/lab11.html

3D visualisation of weather (ii)

- Those examples are not an exhaustive list; other visualisation labs include:
  - MetOffice Informatics Lab;
  - NOAA's Weather and Climate Toolkit;
  - Exelis 4D Weather Visualization Workbench (for NWS)

- Rendering the complexities of the atmosphere in 3D generally means some amount of simplification needs to be made. But….

- 3D visualisation of what is inherently a three dimensional fluid can provide insight into how weather features form, evolve and interact with their environment.

- It can also aid diagnosis and interpretation of the processes involved.

https://www.youtube.com/watch?v=BBfR0HczH1s

The problem

3D visualisation of weather aids interpretation; could analysis of weather features in 3D further our collective understanding?

- Objective identification of weather features in 2D is not trivial; extending this to 3D adds more complexity and computational requirements.

- Is the extension of 2D feature finders to 3D simply by performing 2D analysis at many vertical levels appropriate?
  - How should the features at adjacent vertical levels be associated with one-another to form vertically coherent features?

- Is there a more holistic approach that utilises information in the vertical in addition to the horizontal to identify horizontally and vertically coherent surfaces and/or volumes?

Approaches

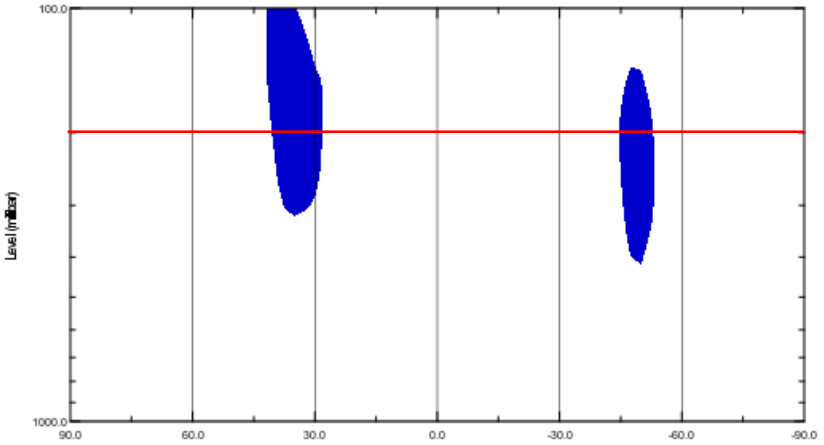
Start with simple 3D volumes and surfaces and build up the complexity

- Use simplified datasets containing basic shapes to investigate possible methods for isolating the outer surface and retrieving the coordinates.

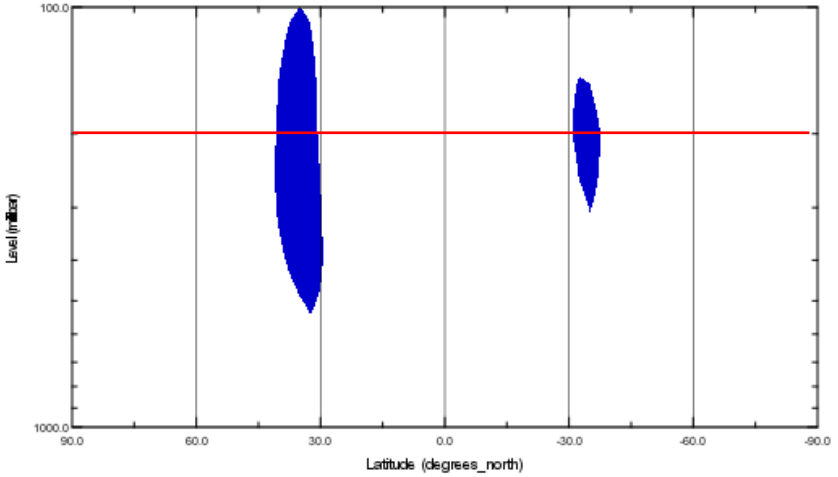
- Apply methods to simplified atmospheric datasets, e.g., jet stream.

Jet stream in 3D

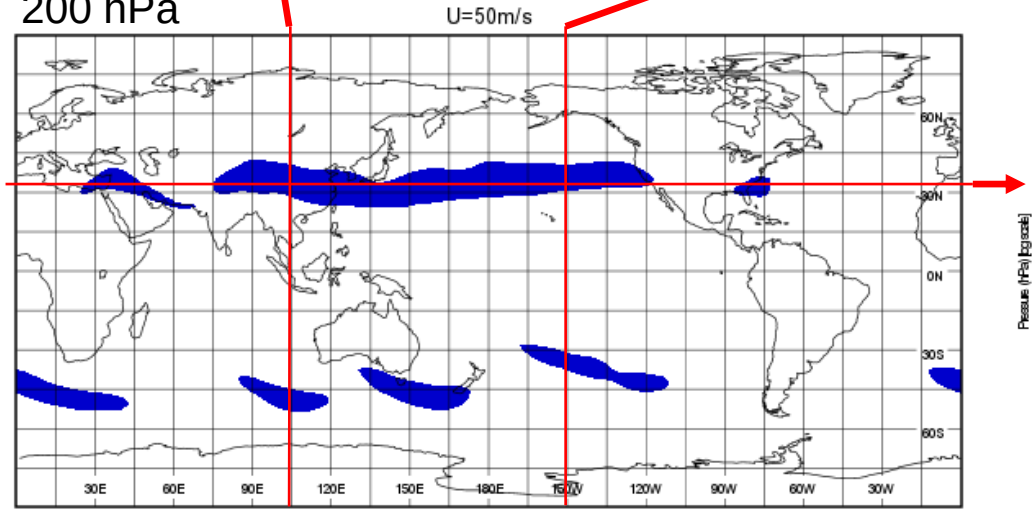
105° E



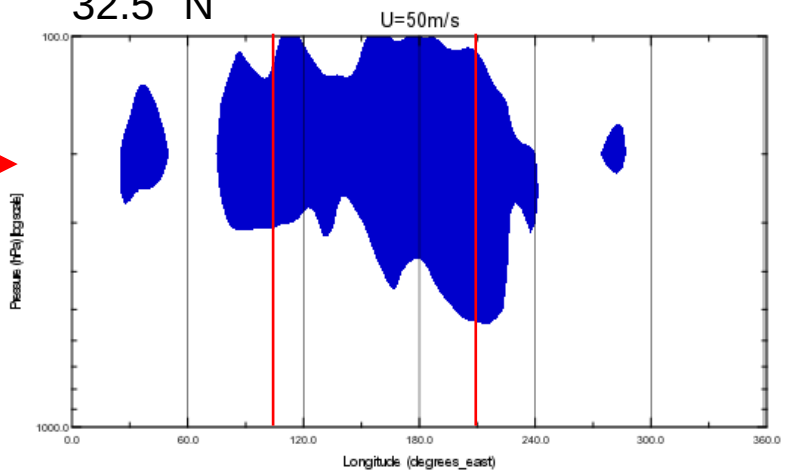
210° E (150° W)



200 hPa



32.5° N



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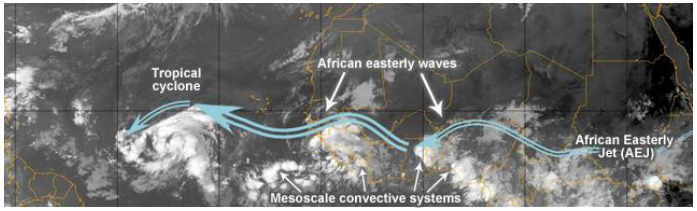
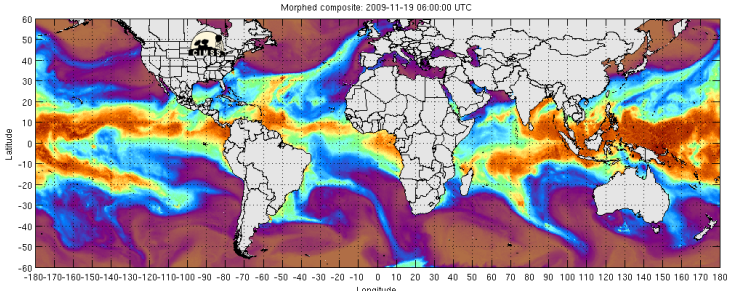
Use existing feature datasets to investigate how to marry data together in vertical

- Easterly waves trough axis



www.meted.ucar.edu

- Atmospheric rivers



tropic.ssec.wisc.edu/real-time/mimic-tpw/global/main.html

Datasets

NCEP/NCAR Reanalysis 1: 2.5°, global, 17 pressure levels, 2006 & 2009

- Zonal wind (u): identify Jetstream
- Zonal and meridional winds (u and u) and specific humidity (q): calculate horizontal water vapour transport to identify atmospheric rivers
    - Atmospheric river axis dataset

ECMWF Interim Reanalysis (ERA-Interim): 1.5°, tropical strip, 37 pressure levels, Jul-Oct 2000

- Zonal and meridional winds (u and v): identify wave trough axis
    - Easterly wave trough axis & tracks dataset

Thank you

Questions?