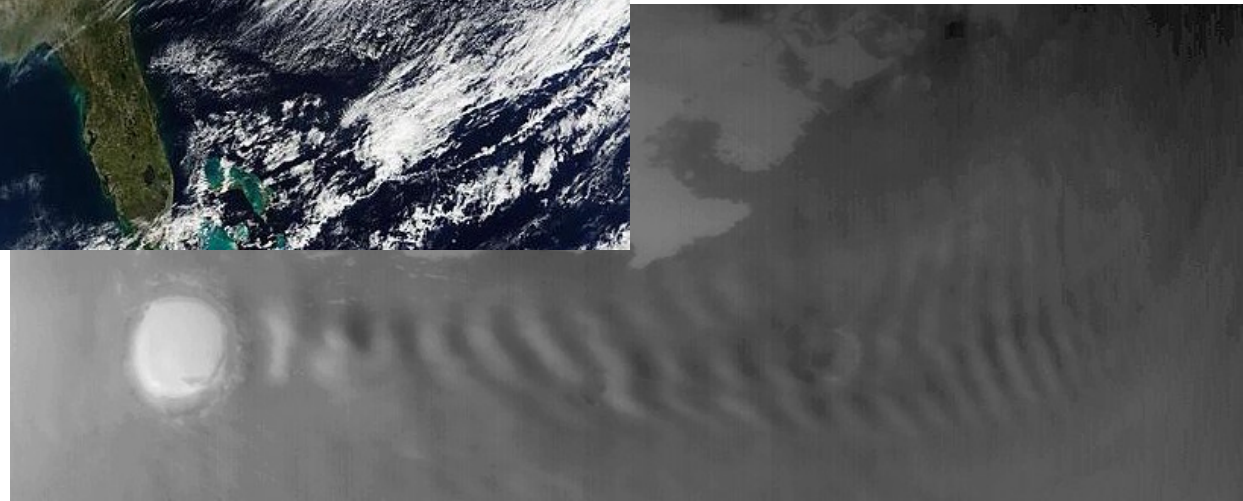
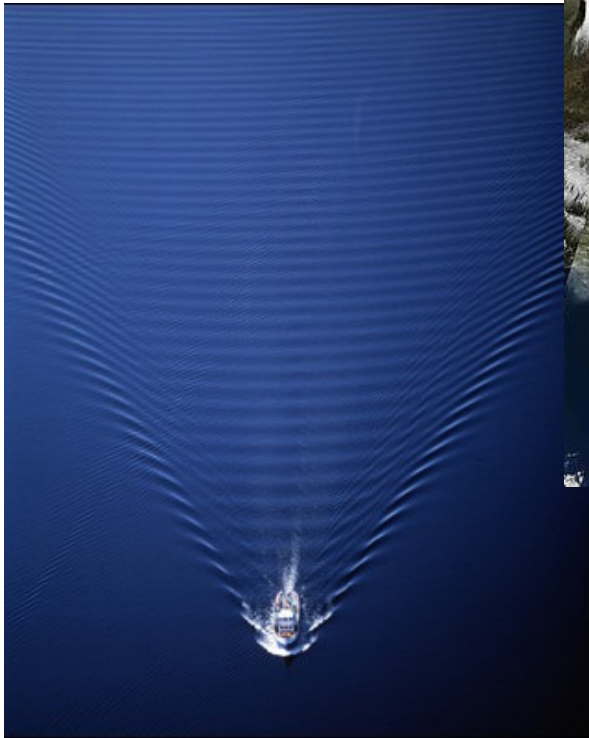
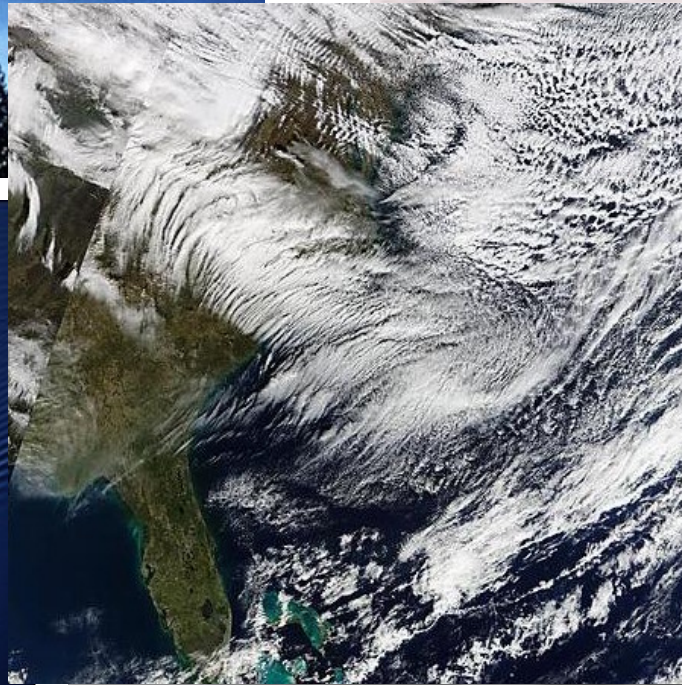
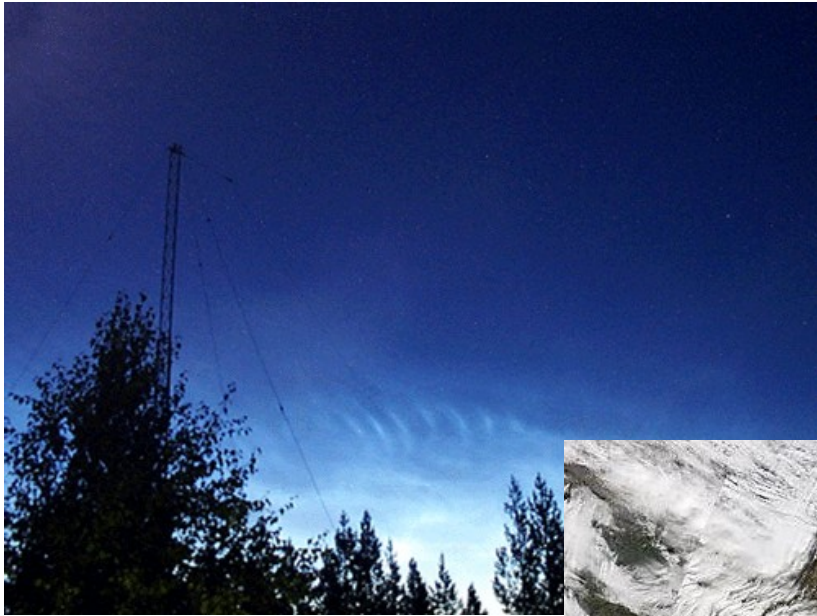


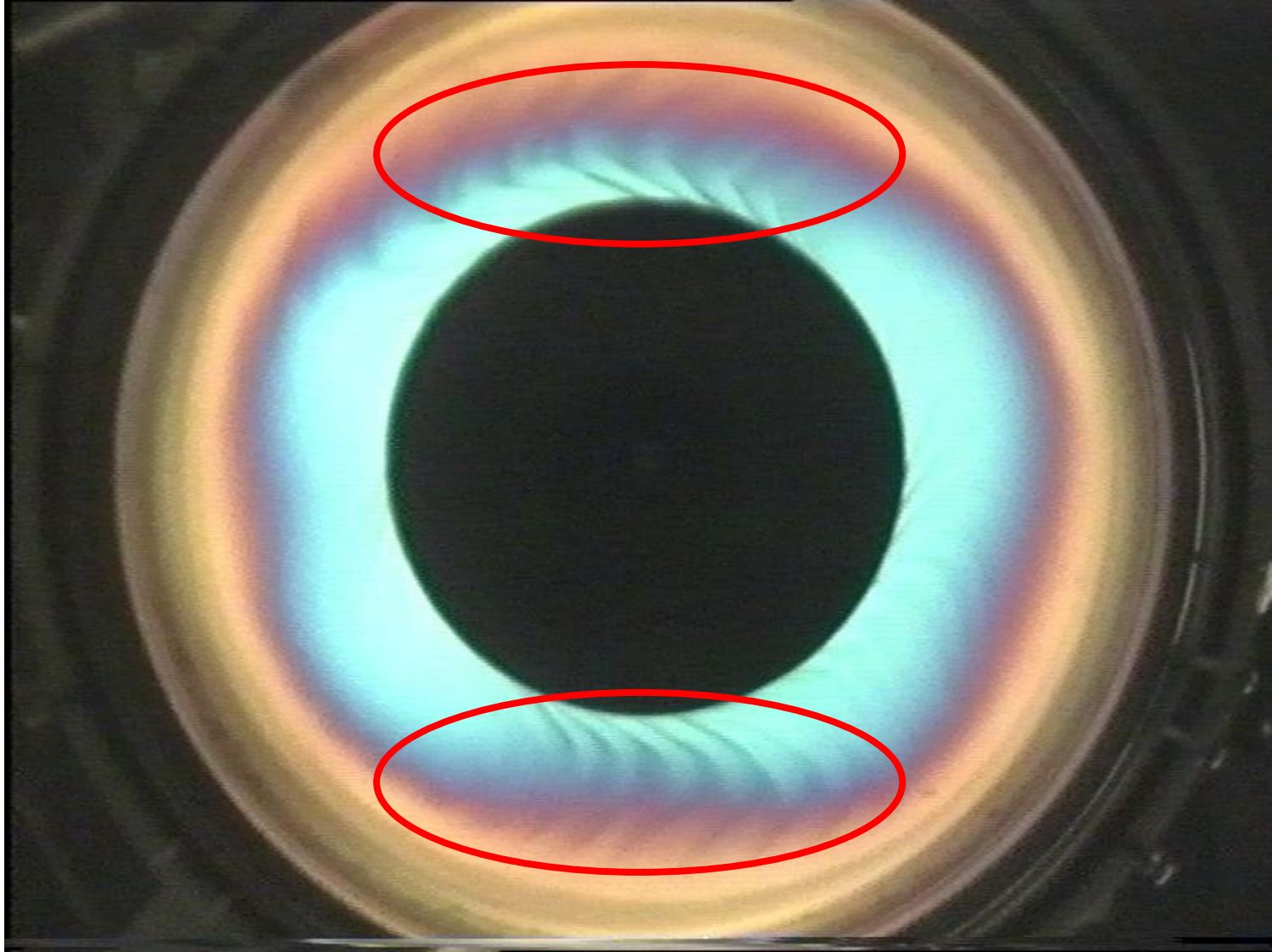
Laboratory observations of inertia-gravity waves

Paul Williams^{*}, Peter Read & Tom Haine

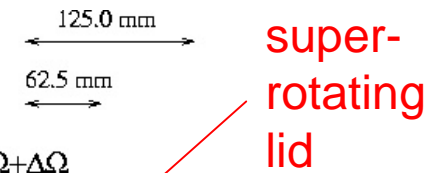
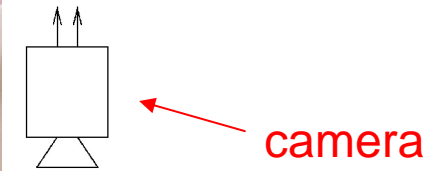
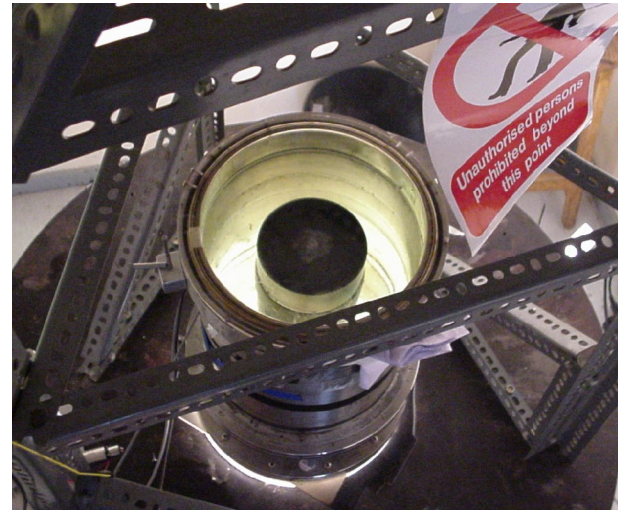
^{*}Walker Institute for Climate System Research, Reading University, UK





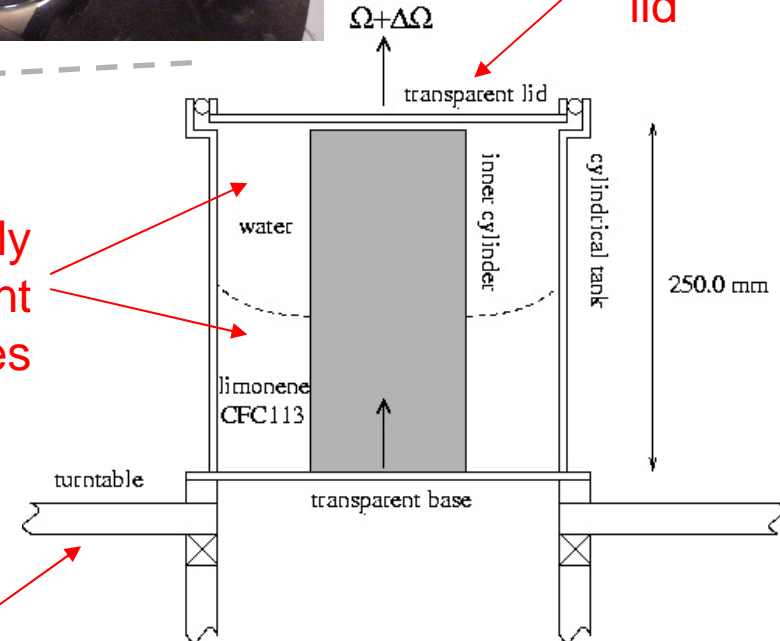


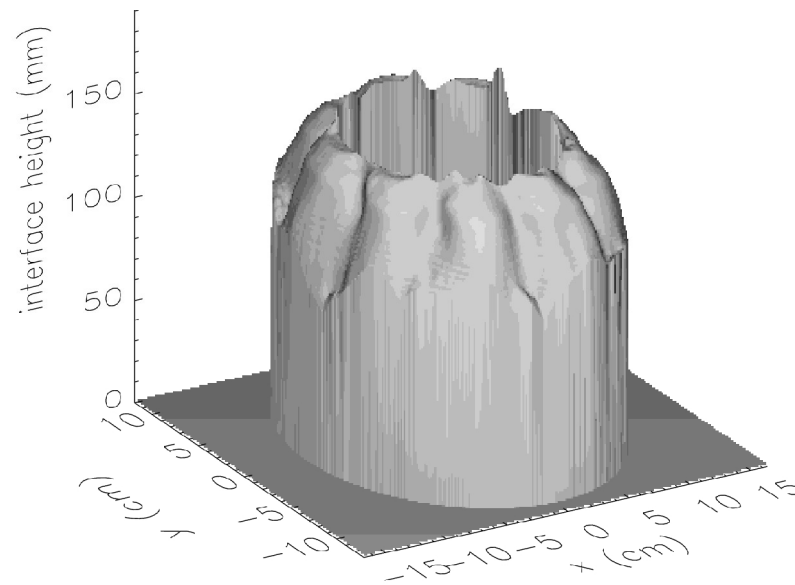
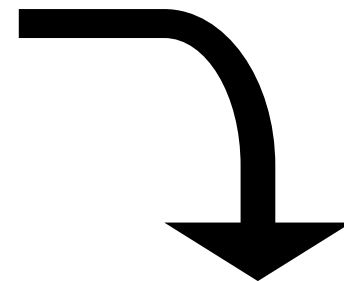
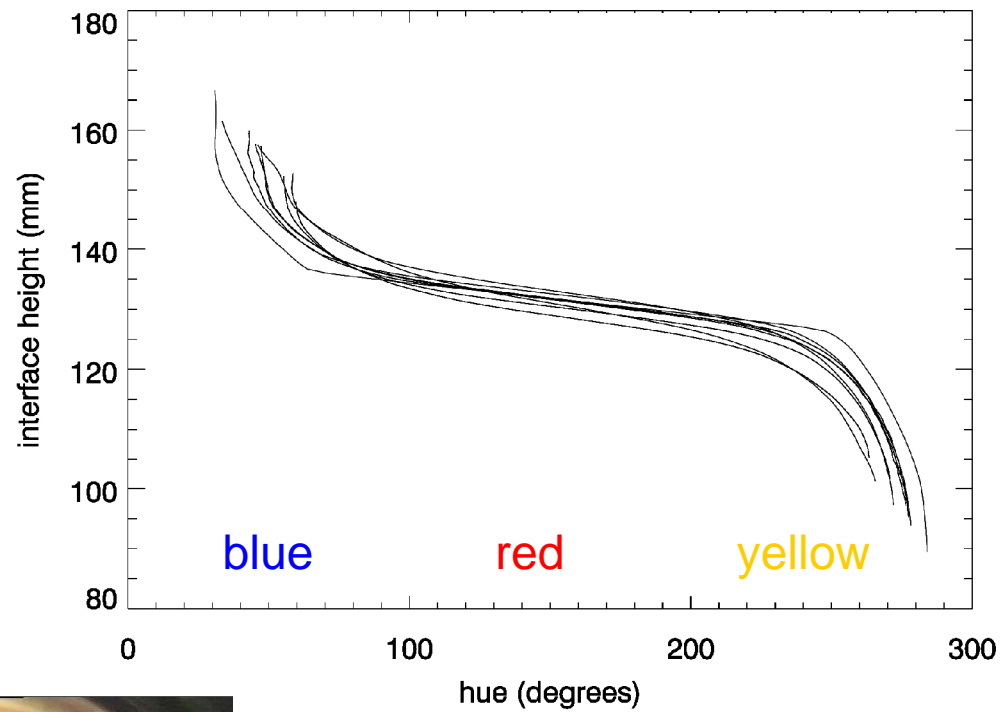
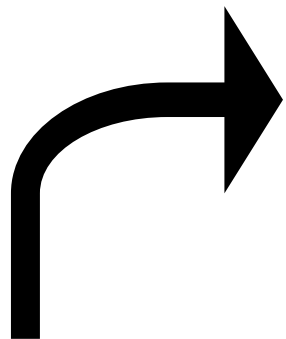
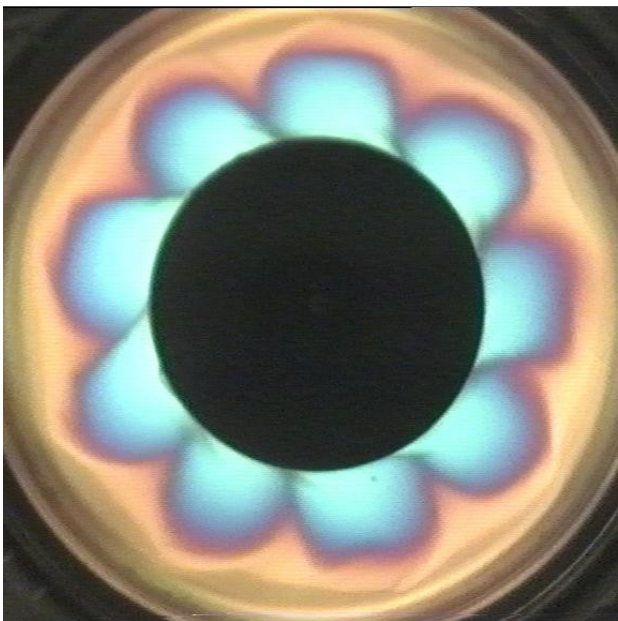
Rotating two-layer annulus experiment



slightly different densities

rotating turntable





Williams, Read & Haine (GAFD; 2004)

A word of warning...!

- “*d-limonene ... can be harmful when vaporized and breathed.*”

US Environmental Protection Agency

- “*... the primary ingredient of Citrus Burst[®], d-limonene, is plant derived. It is extremely safe...*”

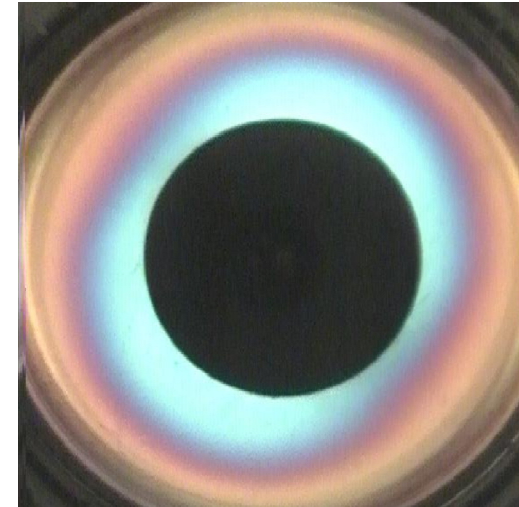
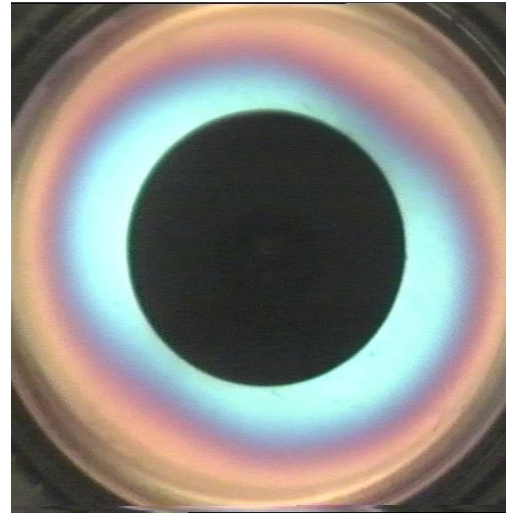
Florida Chemical Company, Inc.

Application #1: polar vortex splits

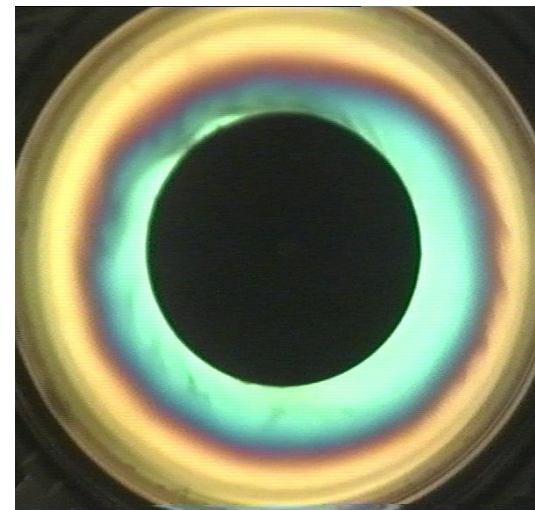
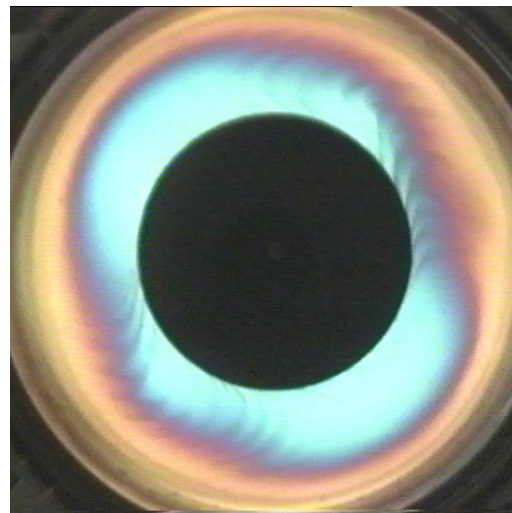
Acknowledgements: Thomas Birner

'Noise'-induced transitions in the lab?

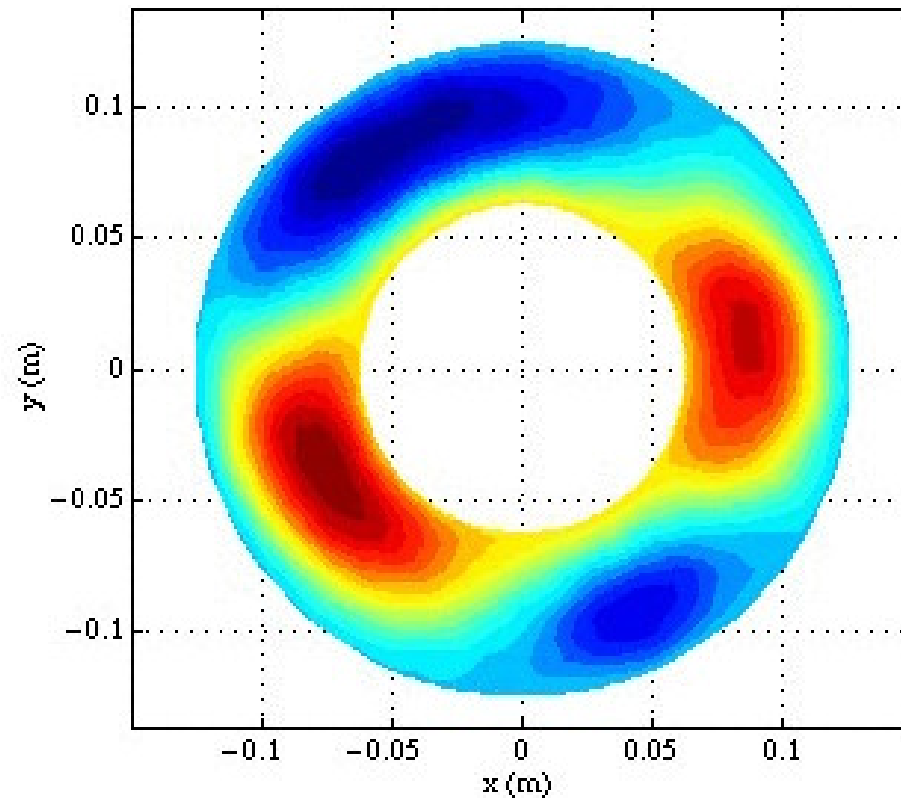
without
gravity
waves:



with
gravity
waves:



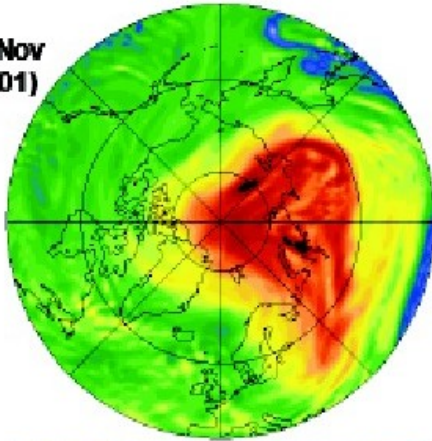
Noise-induced transition in *QUAGMIRE* quasi-geostrophic model



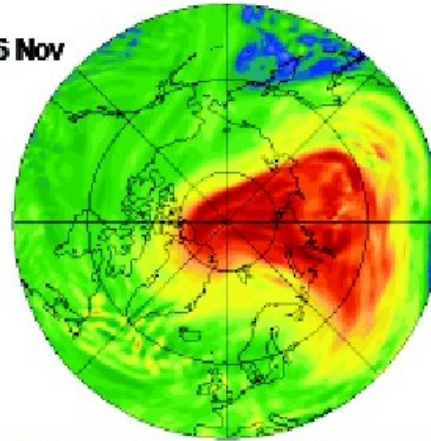
Williams, Read & Haine (GRL; 2003)

Arctic polar vortex split

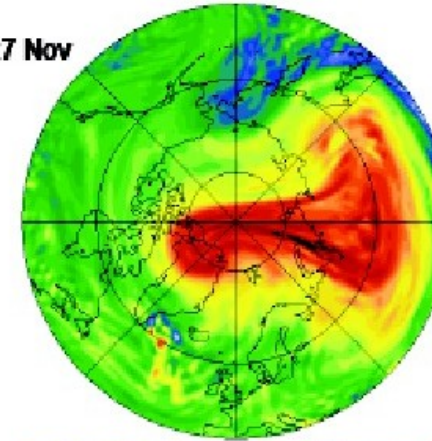
25 Nov
(2001)



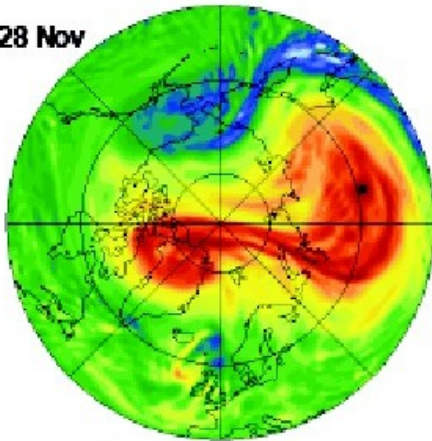
26 Nov



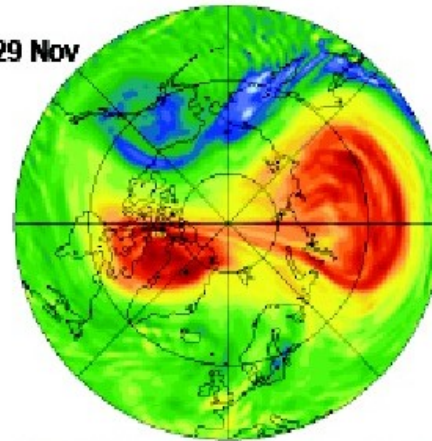
27 Nov



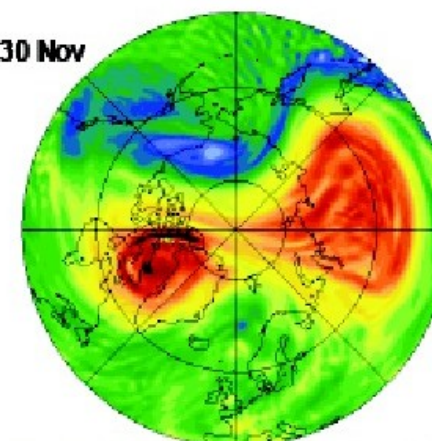
28 Nov



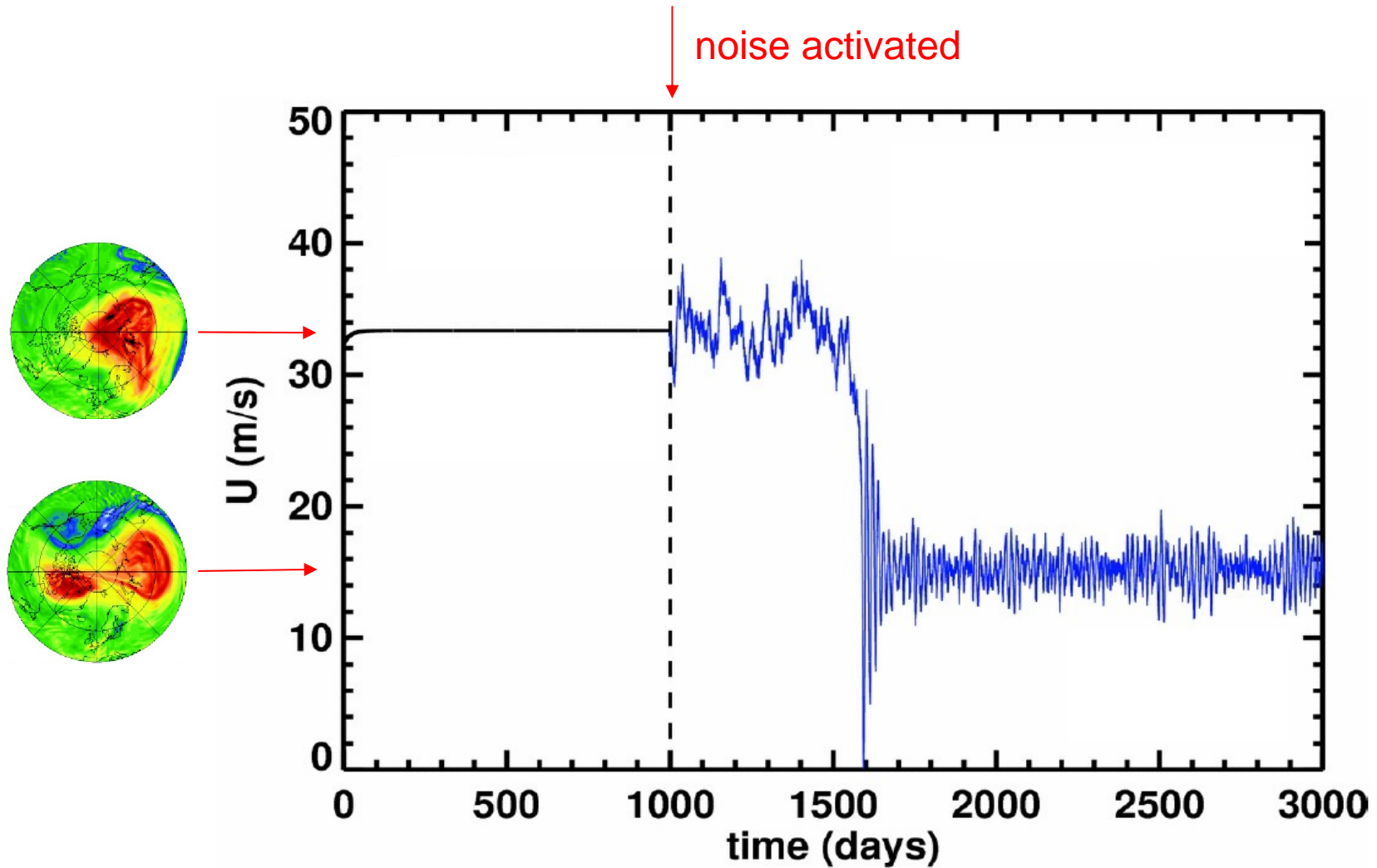
29 Nov



30 Nov



Ruzmaikin et al. (2003) model + noise



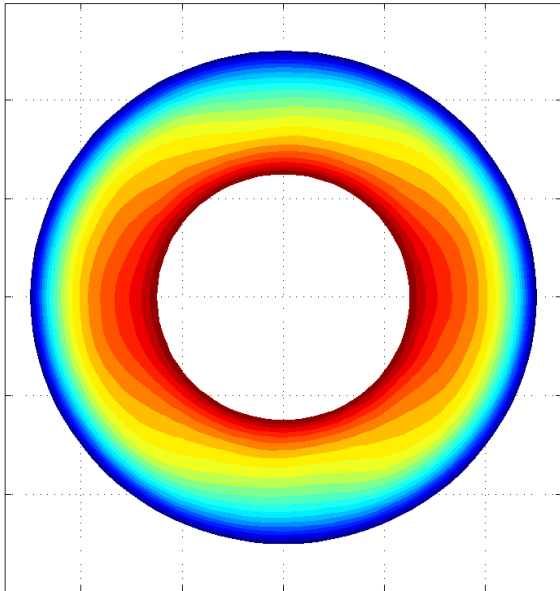
Birner & Williams (JAS; 2008)

Application #2: clear-air turbulence

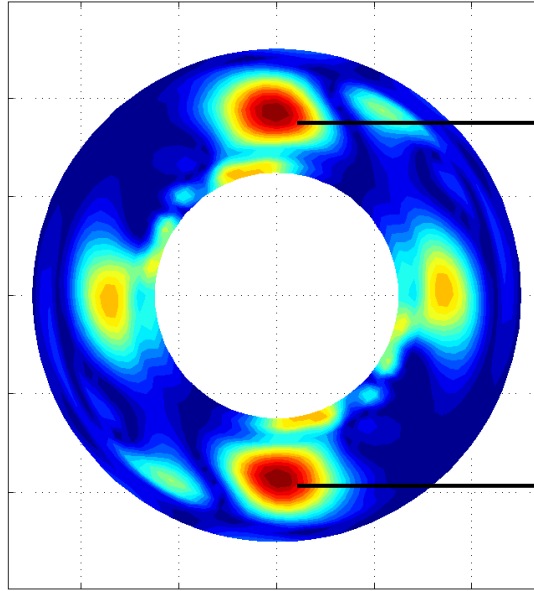
Acknowledgements: John Knox & Don McCann

QUAGMIRE MODEL:

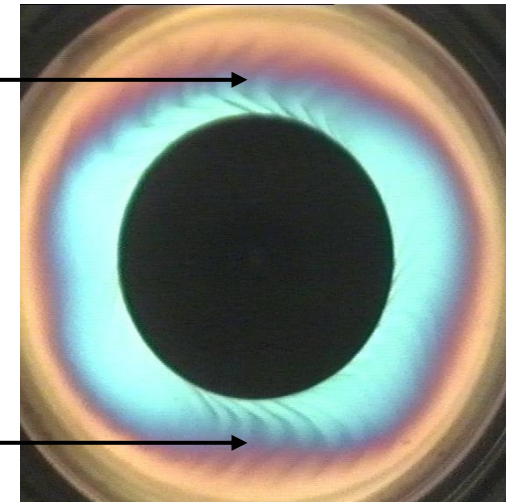
LAB:



interface height

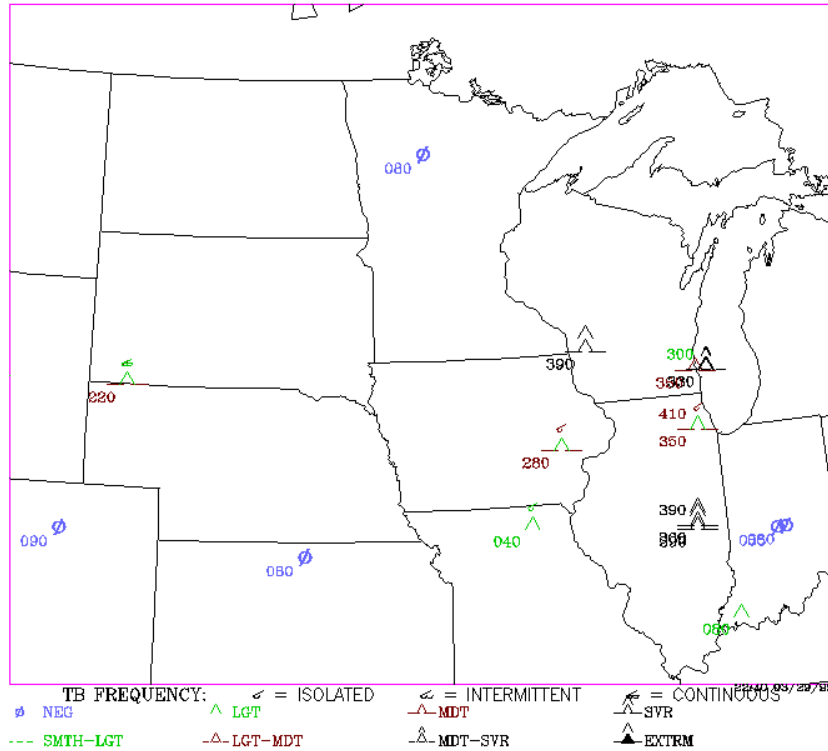


Ford (1994)
IGW source term

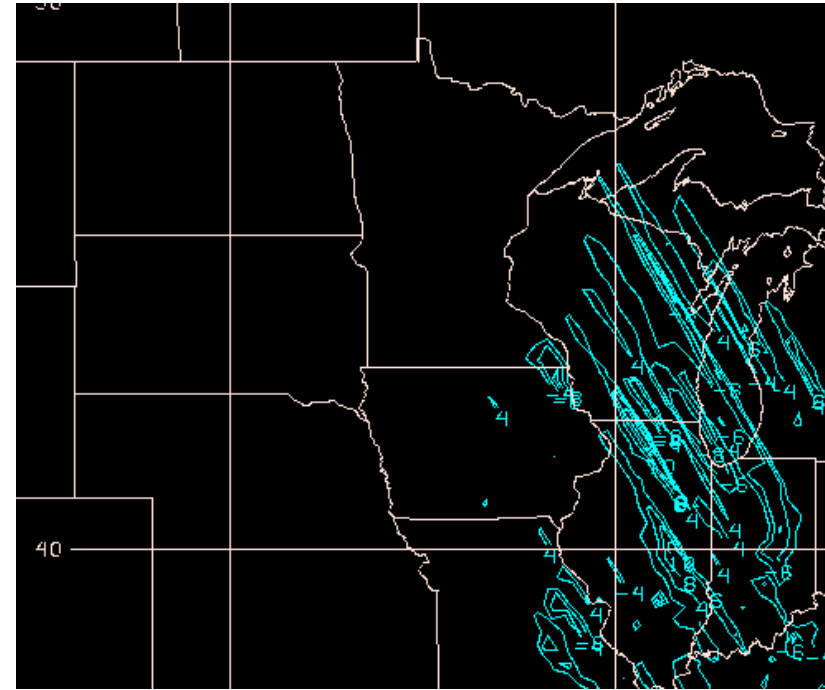


interface height

Pilot Reports (PIREPs) of Turbulence
1303z - 1359z 10/21/96



pilot reports of CAT

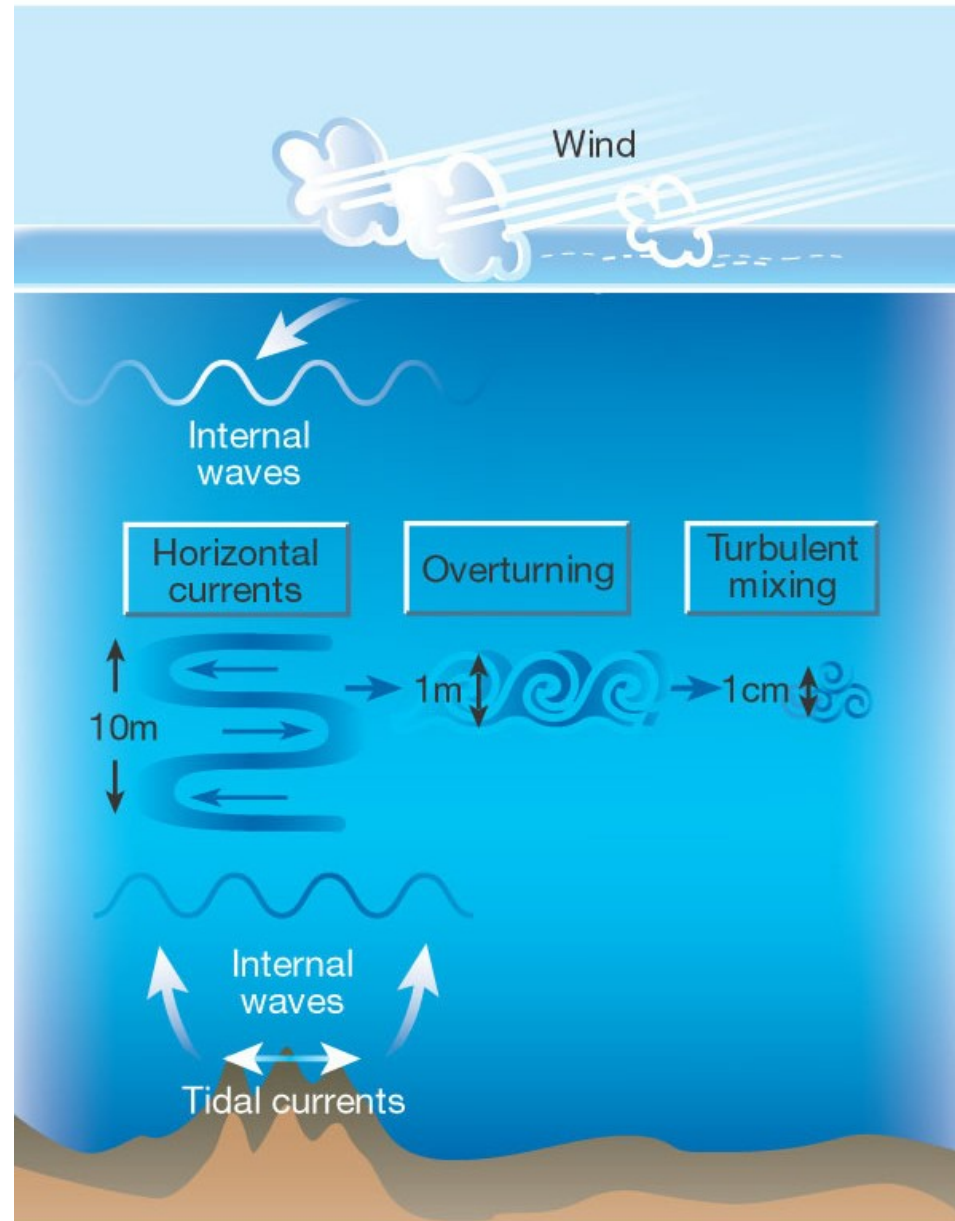


Ford source term calculated using
the *North American Regional
Reanalysis (NARR)*

Knox, McCann & Williams (JAS; 2008)

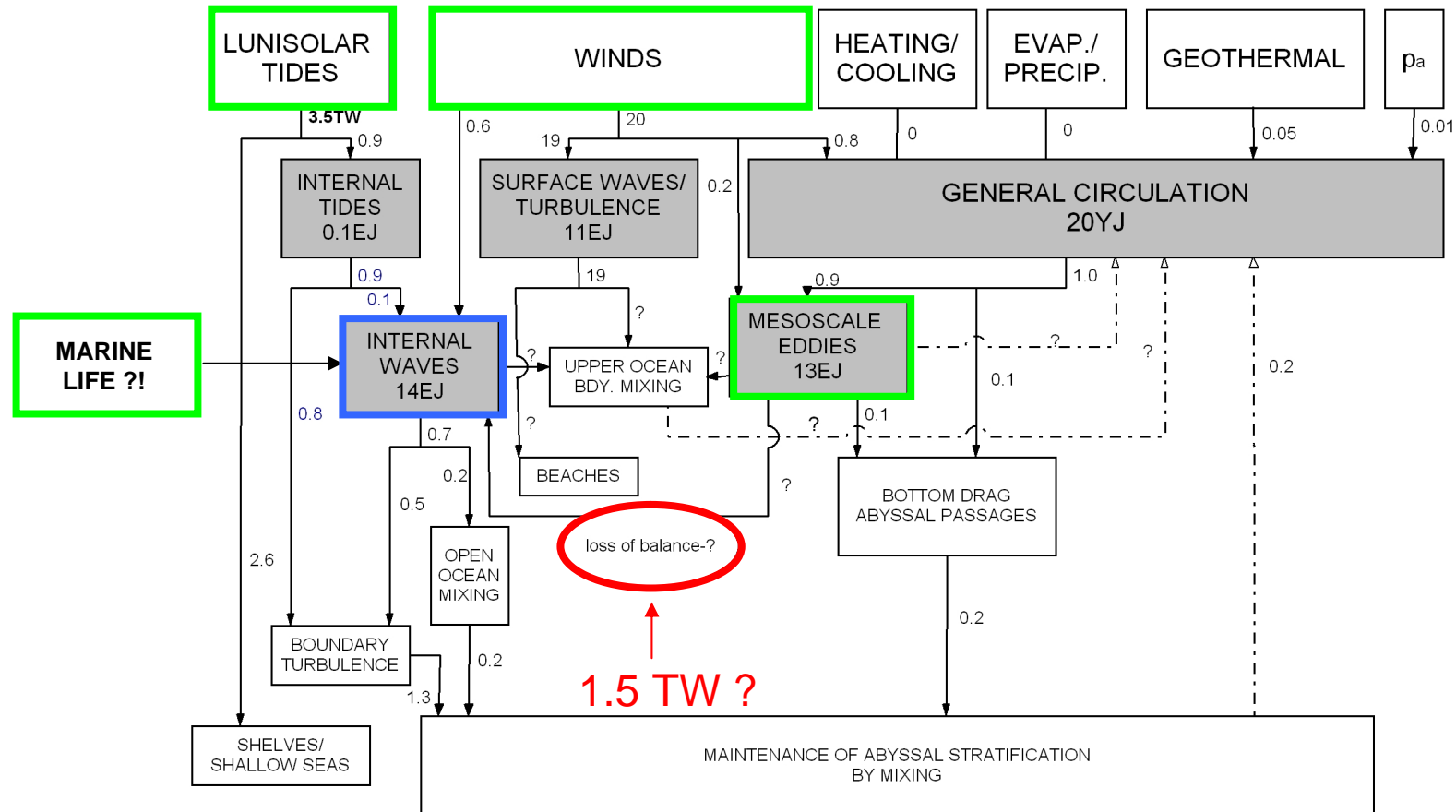
Application #3: deep ocean mixing

Acknowledgements: Tom Haine & Peter Read



Garrett (Nature; 2003)

Energy budget for global ocean circulation



Wunsch & Ferrari (2004)
Williams, Haine & Read (JAS; 2008)

Conclusions

- Laboratory observations of IGWs have inspired new insights into:
 - the dynamics of polar vortex splits
 - the prediction of clear-air turbulence
 - the energetics of deep ocean mixing
- ... and may have a useful role when explaining these phenomena in the classroom