

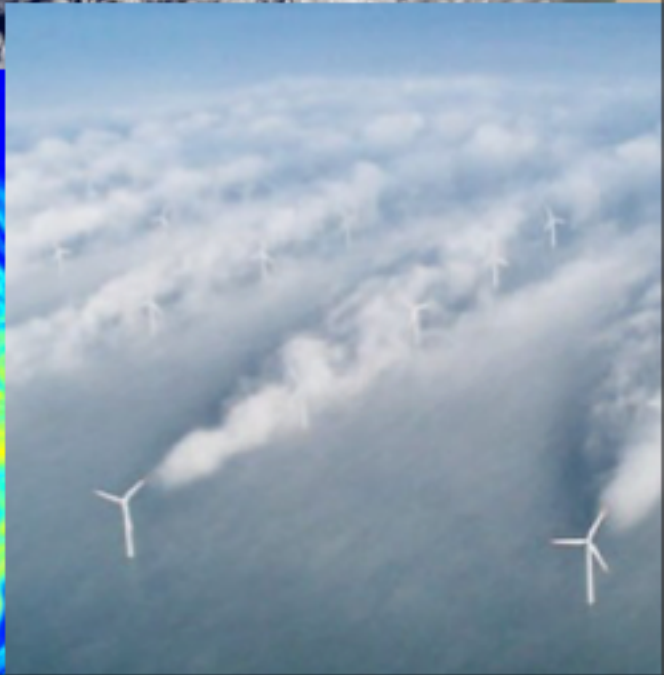
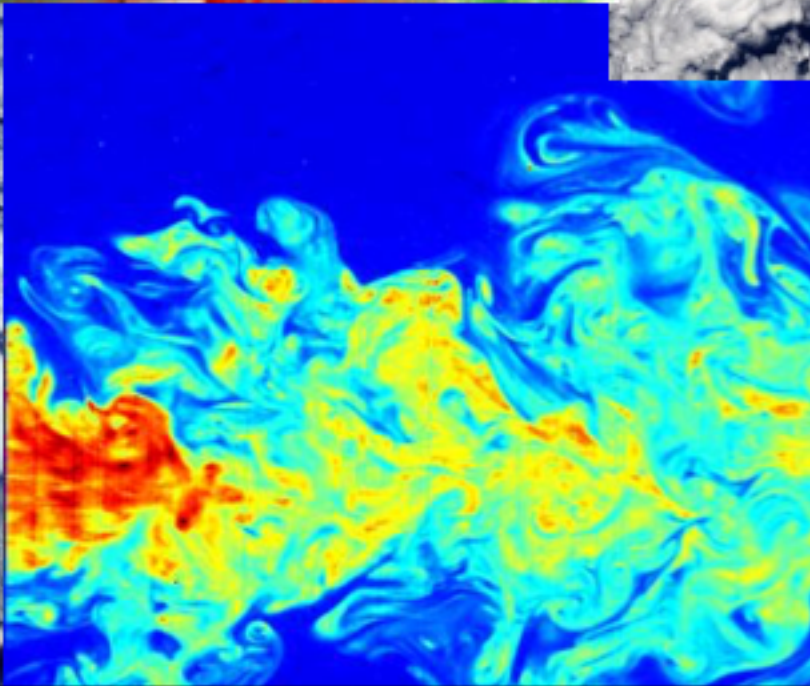
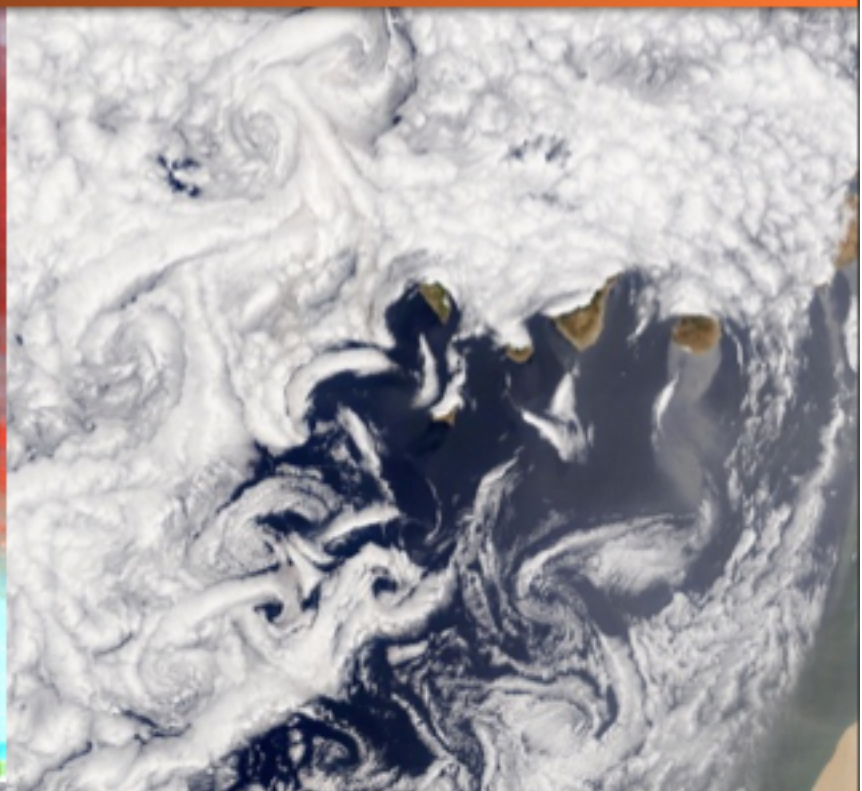
Turbulence Introduction

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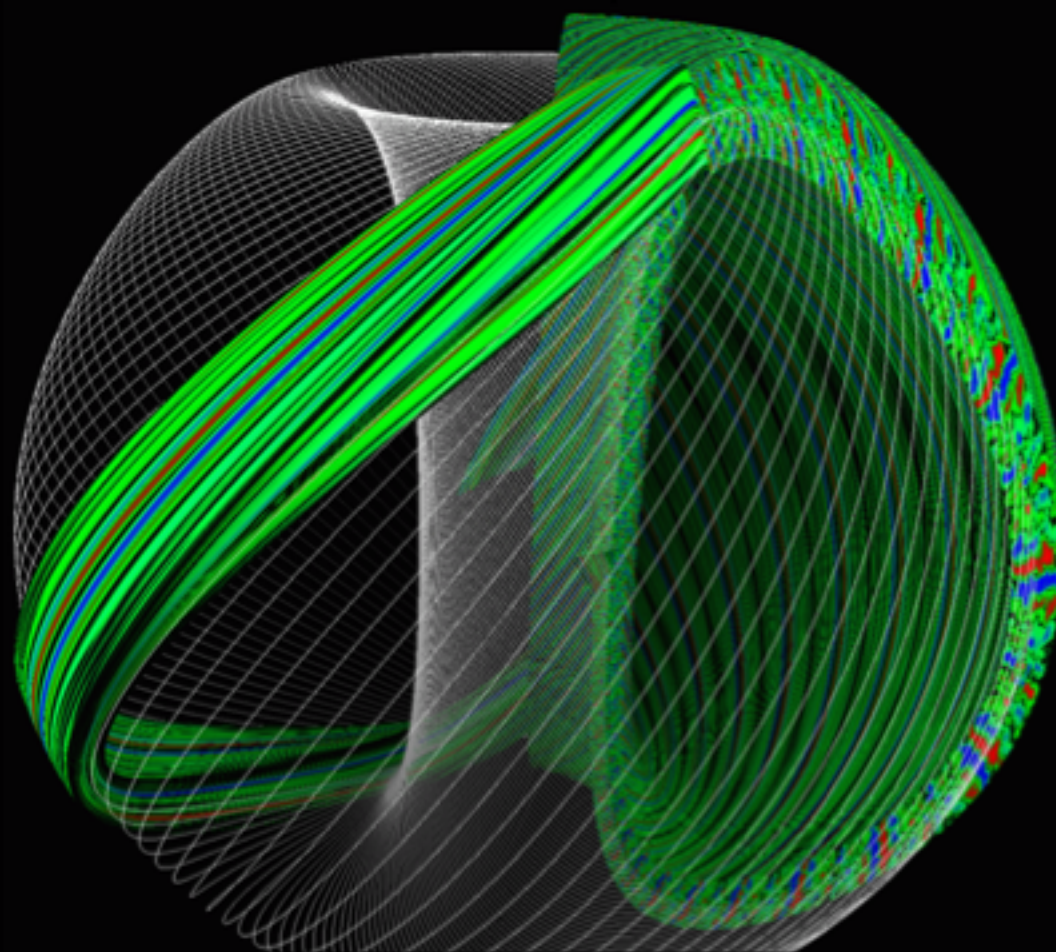
Terrestrial turbulence



Why is turbulence important?

Turbulence plays an important role in a large variety of space, astrophysical phenomena and laboratory plasma experiments, e.g.,

- Accretion discs
- Interstellar medium
- Star-forming nebulae
- Galaxy clusters
- Solar corona and solar wind
- Fusion confinement experiments



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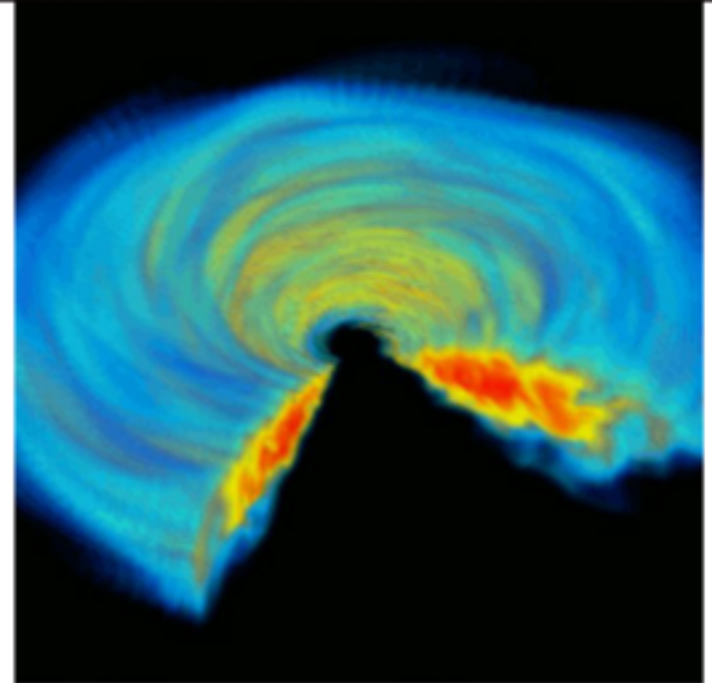
Turbulence is important because it governs the transport of

- **Energy** (energy flow, heating)
- **Mass** (mixing, accretion)
- **Momentum** (jet interactions, shocks)



Accretion discs

- Matter spirals into the black hole, converting a tremendous amount of gravitational potential energy into heat
- This occurs via several processes:
 - Magnetorotational Instability (MRI) drives turbulence
 - Turbulence cascades nonlinearly to small scales
 - Kinetic mechanisms damp turbulence and lead to plasma heating
- Radiation emitted is function of plasma heating, T_i (dim) vs T_e (bright)
- Interpretation of X-ray observations requires understanding of kinetic plasma turbulence and resulting plasma heating



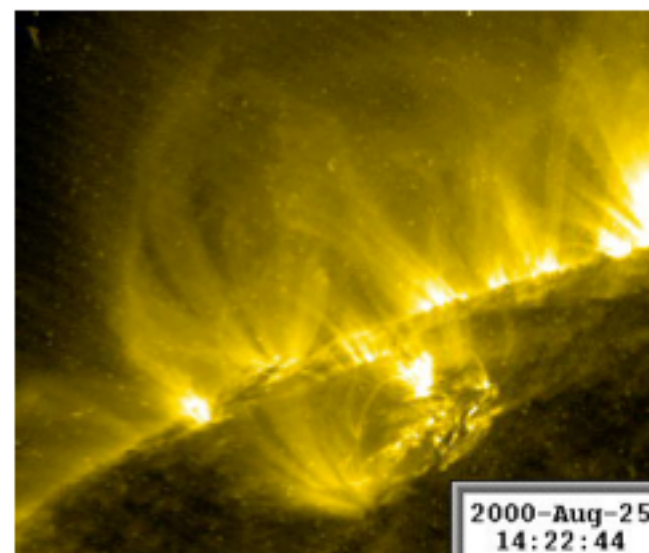
Logarithmic density from an accretion disc simulation by Hawley (2000)

Solar corona

- Important processes not well understood:
 - Heating of the solar corona
 - Acceleration of the solar wind
- Turbulence may play a fundamental role in heating the corona
- Turbulence is driven by:
 - Photospheric footpoint motions
 - Magnetic reconnection



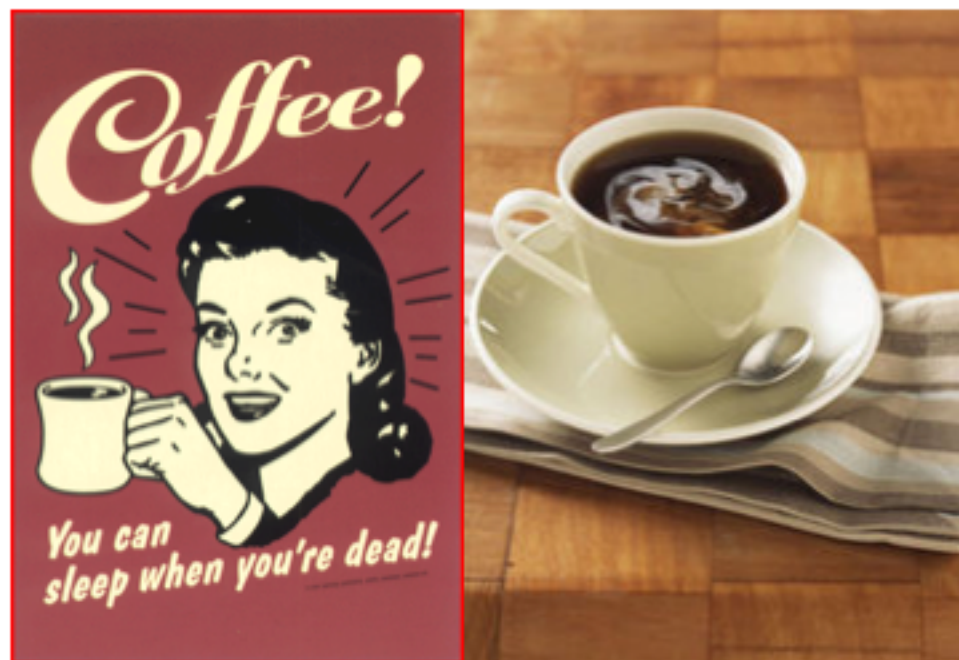
NASA/SDO flare observation from 2/24/2011



NASA/TRACE EUV movie

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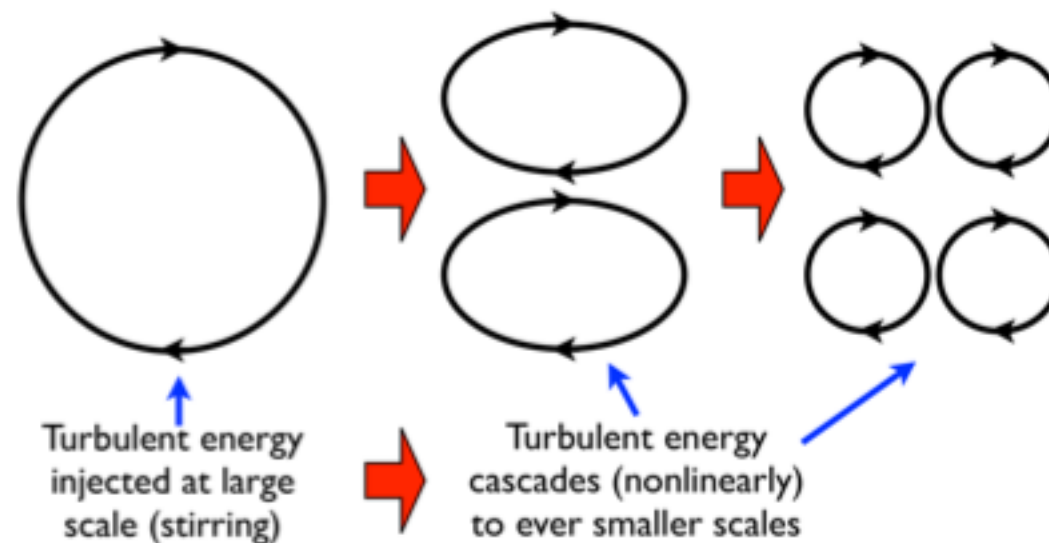
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Cartoon Model of Turbulence



Importance of collisions



Energy spectrum

