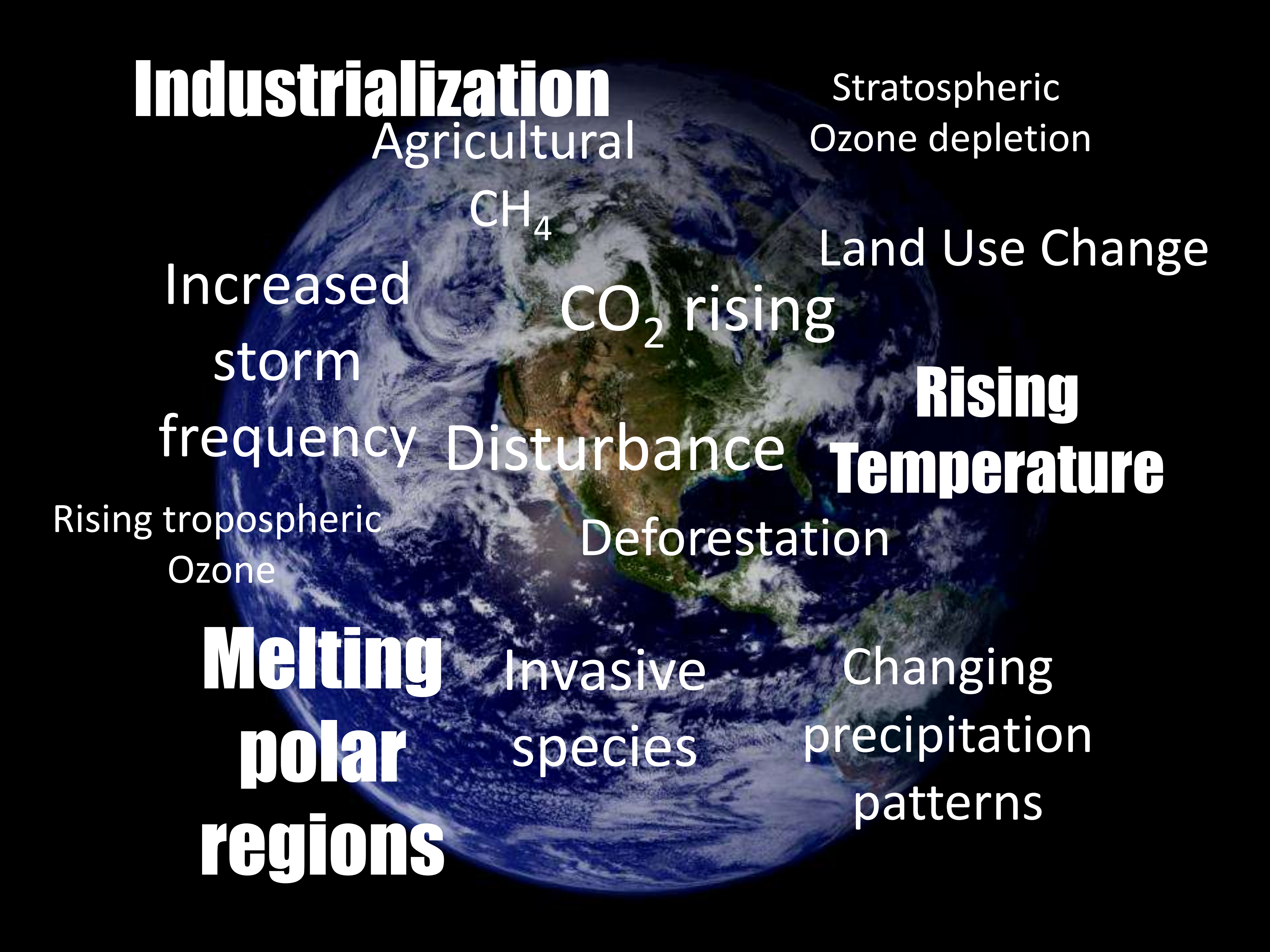
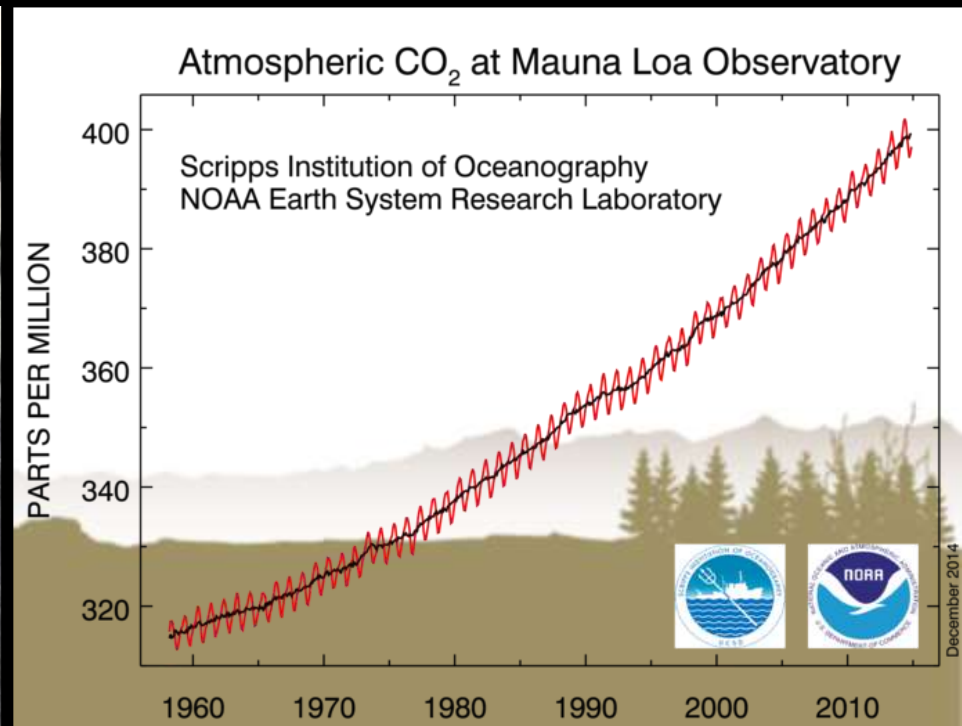
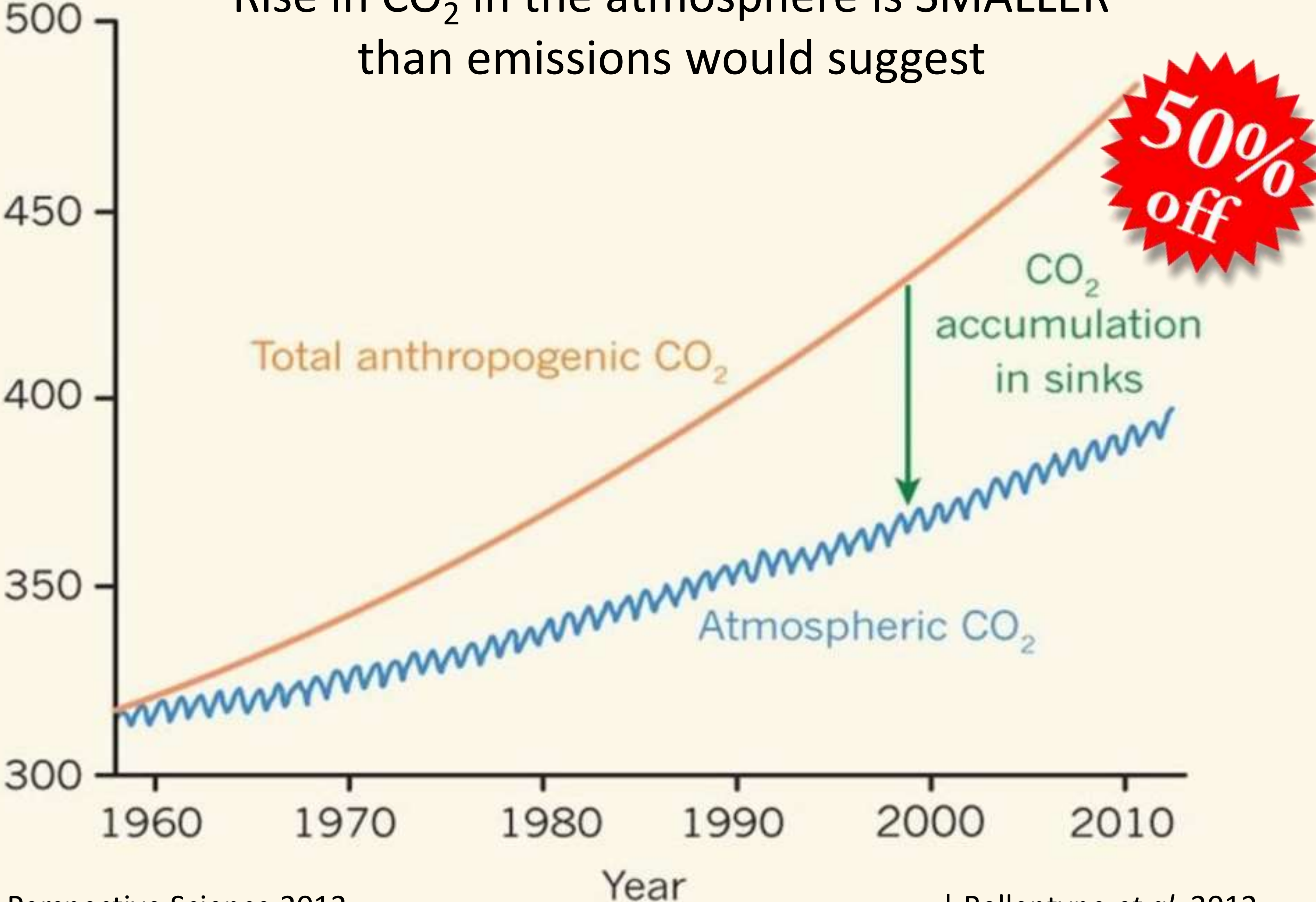
Why are you here?


Industrialization
Stratospheric Ozone depletion
Agricultural CH_4
Land Use Change
Increased storm frequency
CO_2 rising
Rising Temperature
Disturbance
Rising tropospheric Ozone
Deforestation
Melting polar regions
Invasive species
Changing precipitation patterns


DUST STORM APPROACHING SPEARMAN, TEXAS.
APRIL 14. 1935

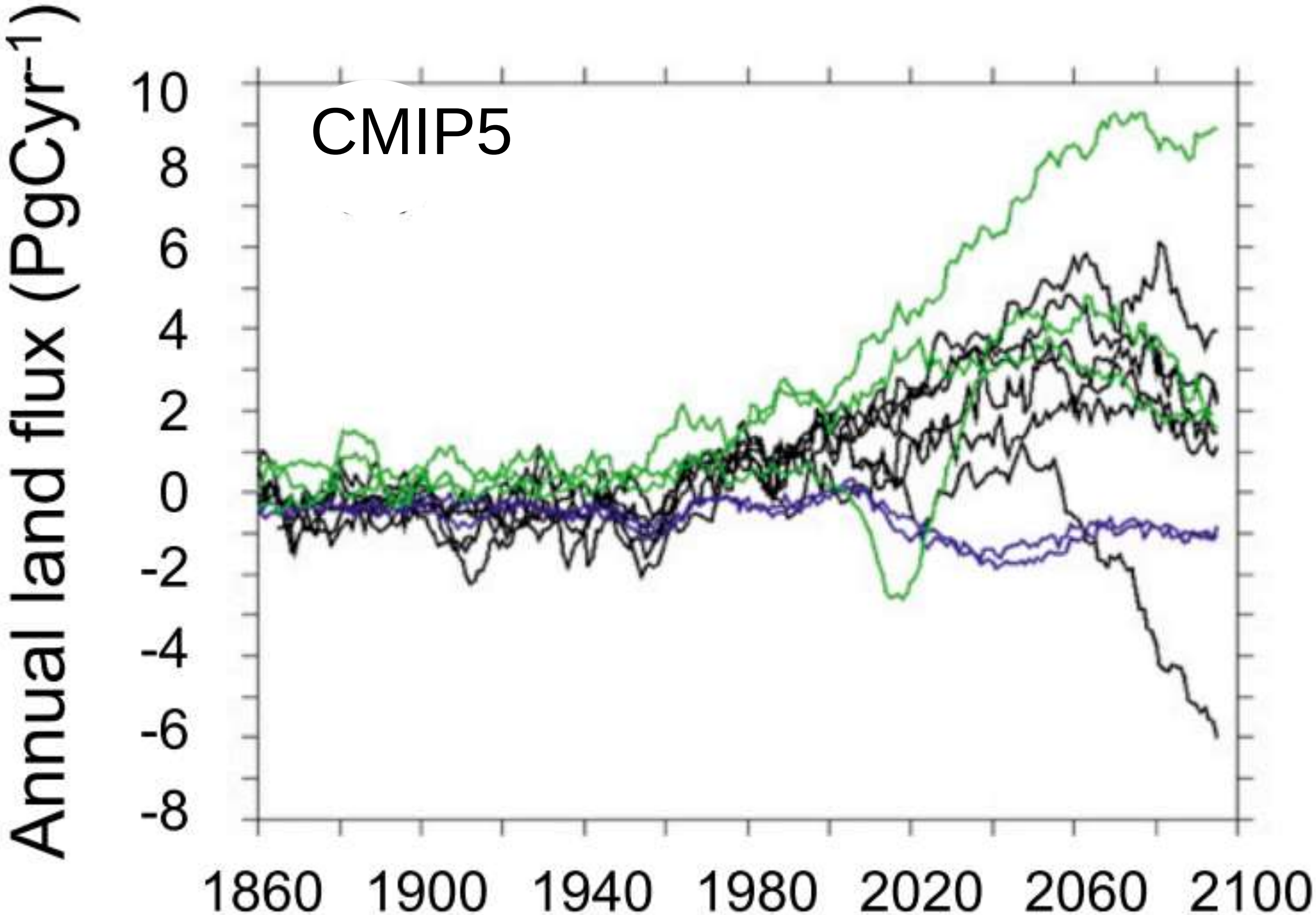

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
380
360
340
320
1960
1970
1980
1990
2000
2010
December 2014

Rise in CO_2 in the atmosphere is SMALLER than emissions would suggest



Perspective Science 2012 | Ballentyne *et al*. 2012

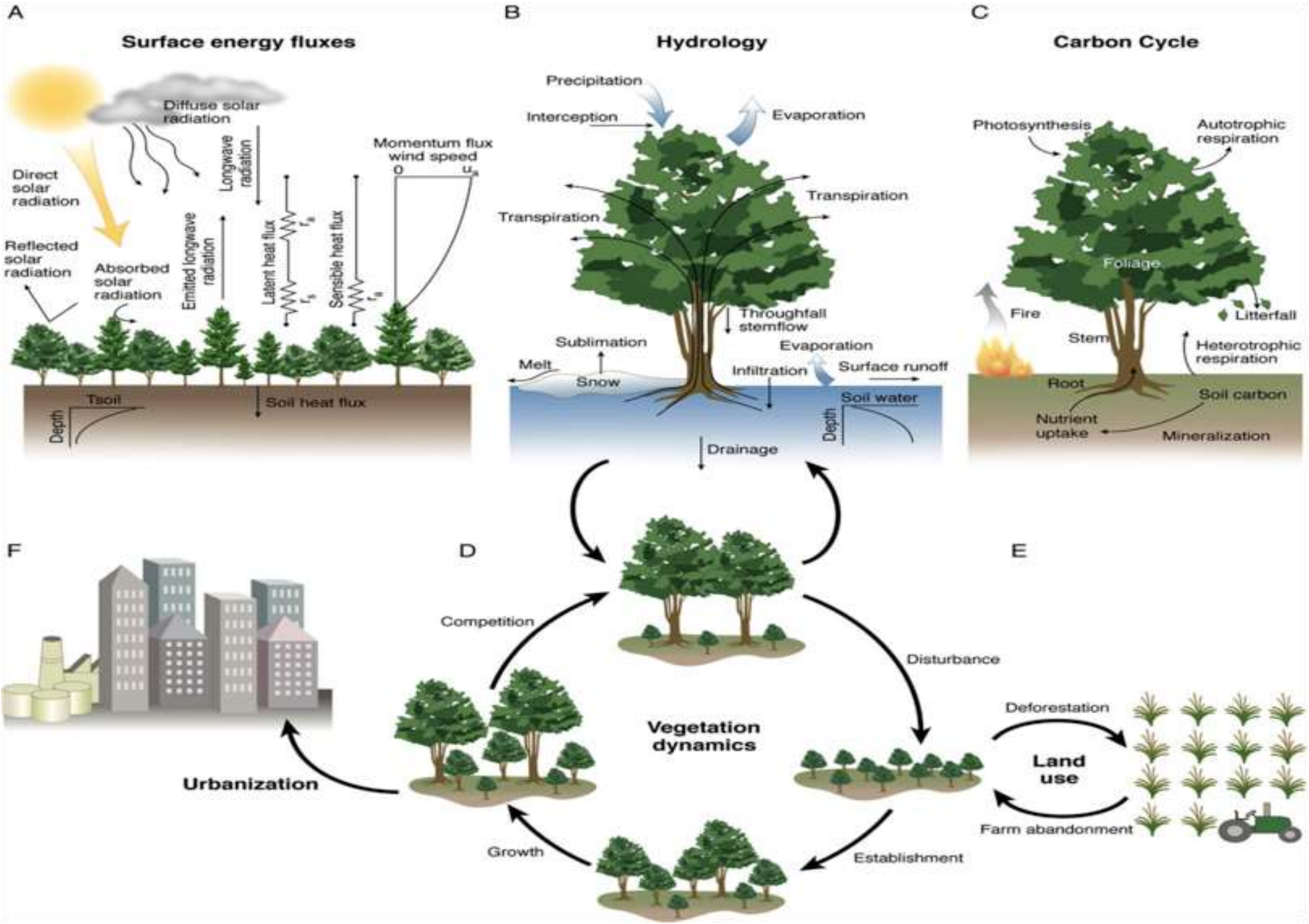
Spaghetti Carbon-Era



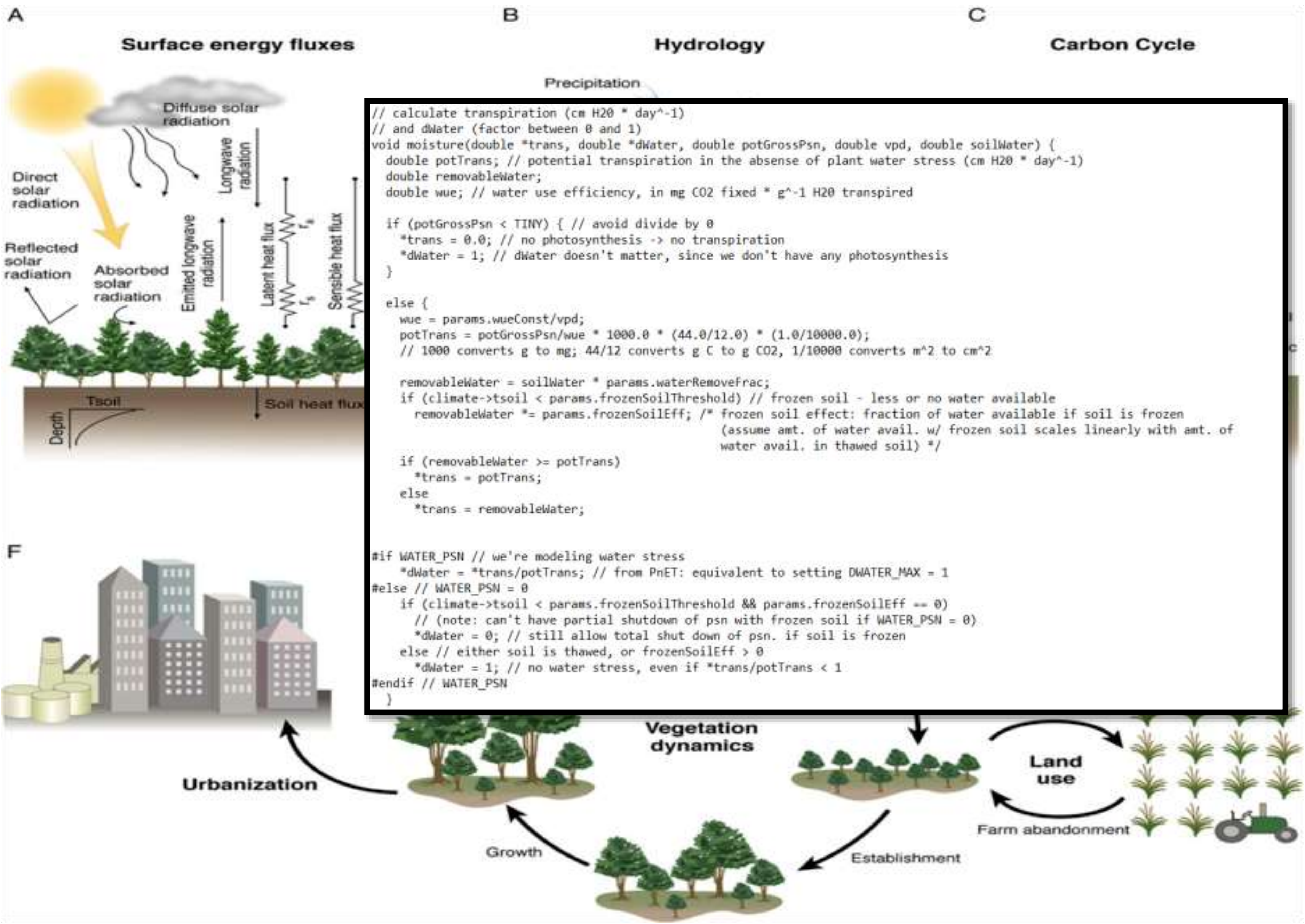
To predict how ecosystems will function in future we need to:

1) Observe ecosystems under different conditions
2) Understand how ecosystems change in response to environmental variation
3) Integrate these responses in sensible ways using process based or statistical models.

Each of these steps requires a specialized skill set



Bonan 2012 Science




```
// calculate transpiration (cm H20 * day^-1)
// and dWater (factor between 0 and 1)
void moisture(double *trans, double *dWater, double potGrossPsn, double vpd, double soilWater) {
  double potTrans; // potential transpiration in the absense of plant water stress (cm H20 * day^-1)
  double removableWater;
  double wue; // water use efficiency, in mg CO2 fixed * g^-1 H20 transpired

  if (potGrossPsn < TINY) { // avoid divide by 0
    *trans = 0.0; // no photosynthesis -> no transpiration
    *dWater = 1; // dWater doesn't matter, since we don't have any photosynthesis
  }

  else {
    wue = params.wueConst/vpd;
    potTrans = potGrossPsn/wue * 1000.0 * (44.0/12.0) * (1.0/10000.0);
    // 1000 converts g to mg; 44/12 converts g C to g CO2, 1/10000 converts m^2 to cm^2

    removableWater = soilWater * params.waterRemoveFrac;
    if (climate->tsoil < params.frozenSoilThreshold) // frozen soil - less or no water available
      removableWater *= params.frozenSoilEff; /* frozen soil effect: fraction of water available if soil is frozen
                                                 (assume amt. of water avail. w/ frozen soil scales linearly with amt. of
                                                 water avail. in thawed soil) */
    if (removableWater >= potTrans)
      *trans = potTrans;
    else
      *trans = removableWater;


#if WATER_PSN // we're modeling water stress
    *dWater = *trans/potTrans; // from PnET: equivalent to setting DWATER_MAX = 1
#else // WATER_PSN = 0
    if (climate->tsoil < params.frozenSoilThreshold && params.frozenSoilEff == 0)
      // (note: can't have partial shutdown of psn with frozen soil if WATER_PSN = 0)
      *dWater = 0; // still allow total shut down of psn. if soil is frozen
    else // either soil is thawed, or frozenSoilEff > 0
      *dWater = 1; // no water stress, even if *trans/potTrans < 1
#endif // WATER_PSN
  }
```

Bonan 2012 Science

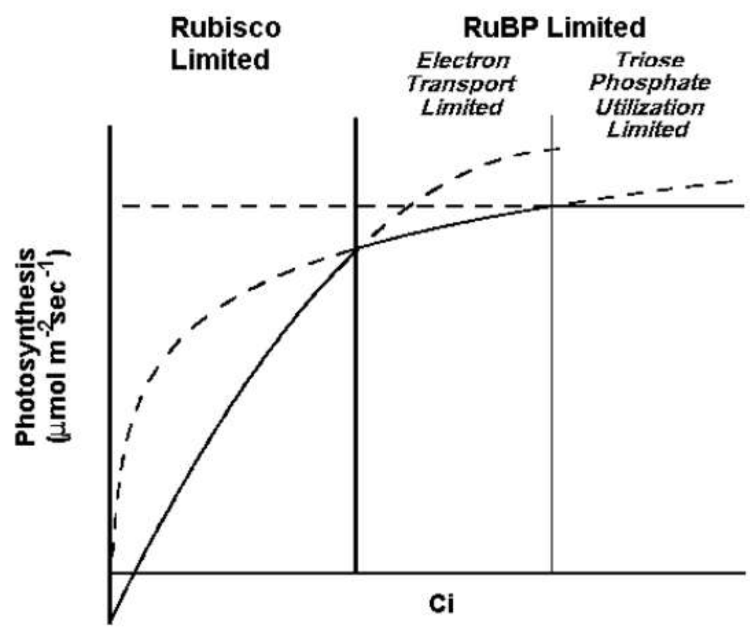
Field Observations

Pat & Aaron

Physiological Theory & models

Chloroplast- and Leaf-Level Flux Modeling

$$A = V_c - 0.5V_o - R_d$$

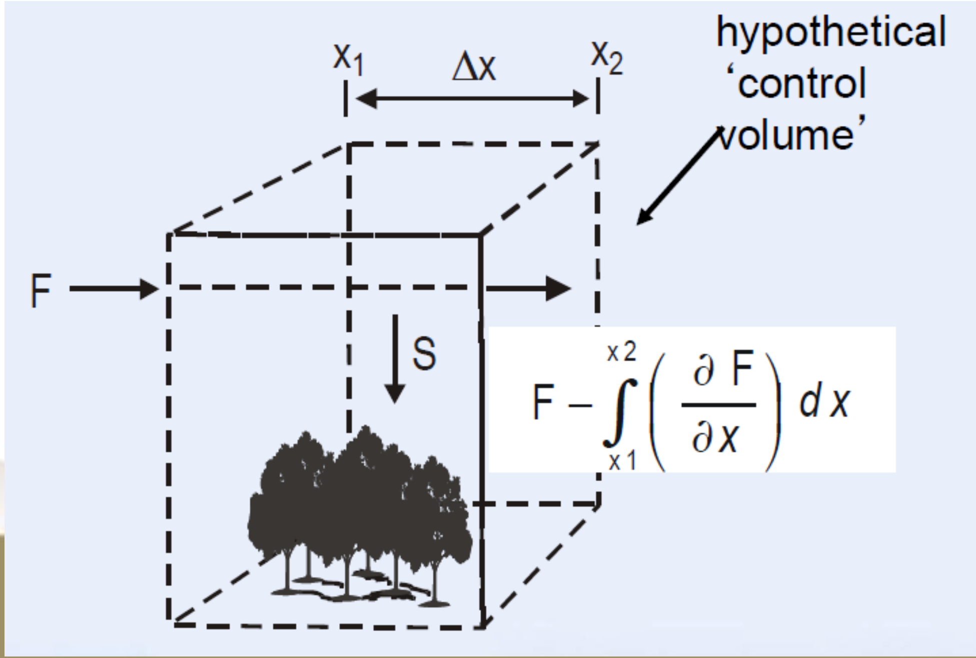


$$A = \min\left\{w_c, w_j, w_p\right\}(1 - \Gamma^* / C) - R_d$$

Pat & Aaron

Theory of the eddy flux, measurements, calibration

Russ Monson
Ed Swiatek
James Kathliankal



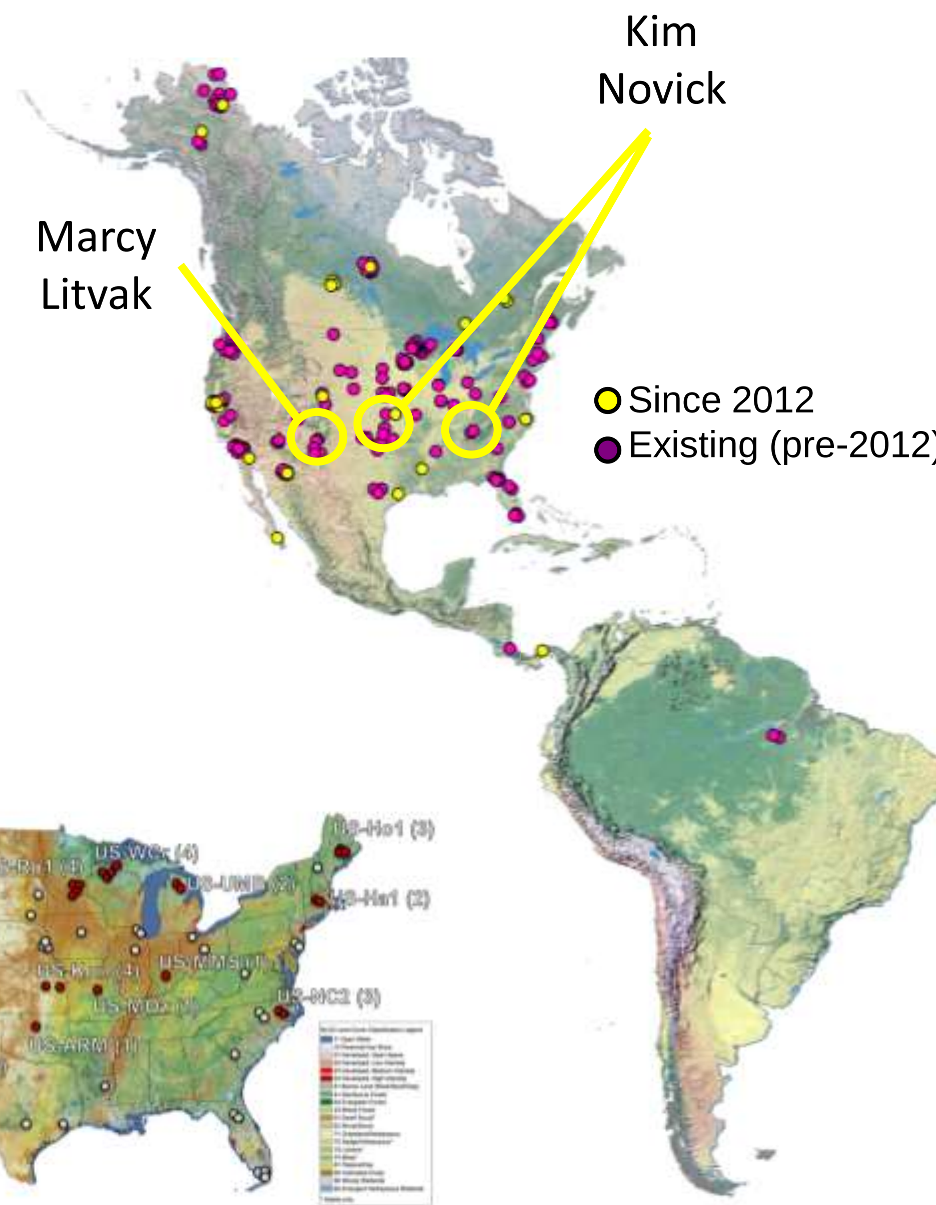

Ed, Ivan, Ryan & Ben
CAMPBELL SCIENTIFIC
Peer teaching

Processing real data warts and all … Ed

Application of flux observations

AmeriFlux Sites

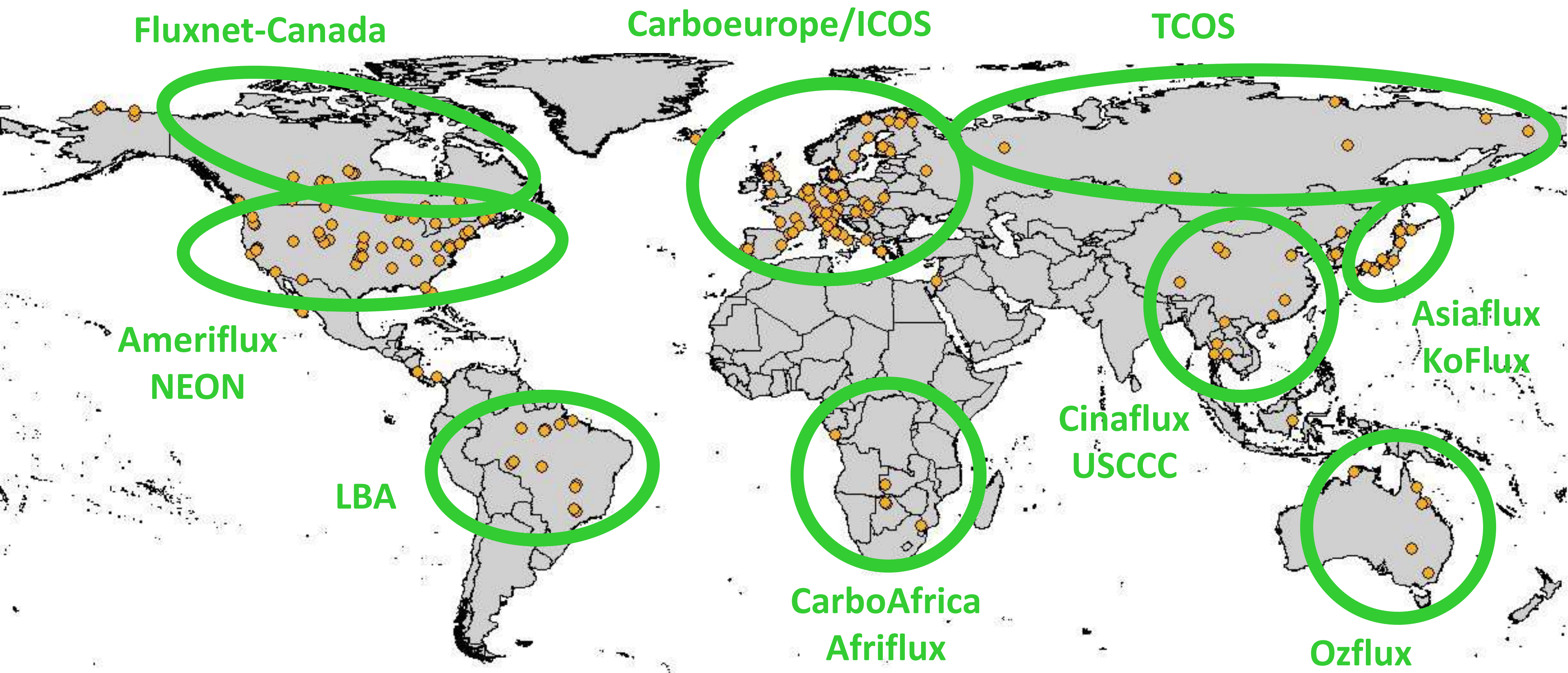
- **Total number: 183**
- **Sites joined since 2012: 26**
- **Sites that uploaded data 2010–2014: 62**
- **Core sites with long term funding: 15 clusters > 41 sites**



AMERIFLUX

http://ameriflux.lbl.gov

Eddy covariance sites are world-wide distributed and organized in regional networks



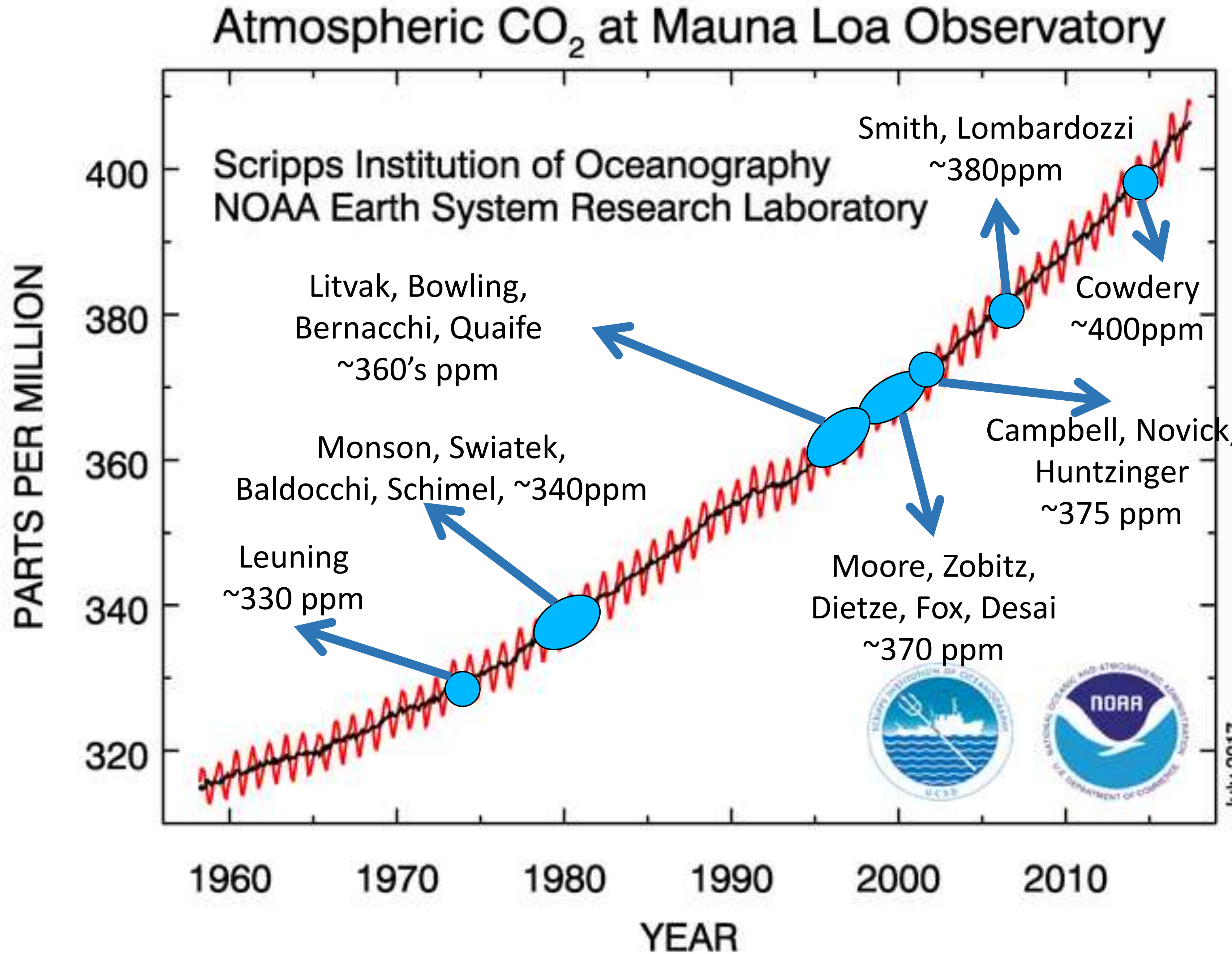
AmeriFlux AsiaFlux KoFlux LBA Fluxnet Canada CARBO EUROPE

AfriFlux ChinaFLUX OzFlux Australian and New Zealand flux Research and Monitoring USCCC NECC Nordic Centre for Studies of Ecosystem Carbon Exchange and its Interactions with the Climate System TCOS SIBERIA

Course Components

- Lectures – recorded for later reference
- Hands on data collection
- Build an eddy-covariance tower
- Manually adjust fluxes to deal with real world glitches
- Graphing, analyzing and inferring ecological meaning in teams
- Downloading and manipulating satellite remote sensing information for the students own site.
- Hands on modeling and data assimilation exercises – working in groups with advice from 4-5 instructors.

Incomplete list of instructors


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
YEAR
July 2017
Smith, Lombardozzi ~380ppm
Cowdery ~400ppm
Litvak, Bowling, Bernacchi, Quaife ~360's ppm
Campbell, Novick, Huntzinger ~375 ppm
Monson, Swiatek, Baldocchi, Schimel, ~340ppm
Moore, Zobitz, Dietze, Fox, Desai ~370 ppm
Leuning ~330 ppm

What we hope you learn

Rule 1: Be a scientist – making measurements doesn't make you an 'empiricist' ; using models doesn't make you a 'modeler'

Rule 2: Know your discipline well

Rule 3: Respect other disciplines – don't expect others to you know your discipline in as much detail as you

Rule 4: Explain yourself

Rule 5: Listen carefully

Rule 6: Work together to solve problems

Spaghetti Carbon-Era