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<https://github.com/julianmak/academic-notes>

The repository principally contains the compiled products rather than the source for size reasons.

- ▶ Associated Python code (as Jupyter notebooks mostly) will be held on the same repository. The source data however might be big, so I am going to be naughty and possibly just refer you to where you might get the data if that is the case (e.g. JRA-55 data). I know I should make properly reproducible binders etc., but I didn't...
- ▶ I do not claim the compiled products and/or code are completely mistake free (e.g. I know I don't write Pythonic code). Use the material however you like, but use it at your own risk.
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OCES 2003 : Descriptive Physical Oceanography

(a.k.a. physical oceanography by drawing pictures)

Lecture 1: “big picture”

Tue 2nd Feb

Outline

- ▶ canvas, Zoom and admin things
- ▶ approach of the course
 - focus on qualifying things (e.g. via drawing pictures)
 - little bit of quantification (no more than multiplying some numbers together)
- ▶ what is **physical oceanography** + why should you care?
 - climate, biogeochemistry, ecology, engineering, trade, law, policy etc. (maybe even just curiosity?)

Ocean physics is not easy, but you need enough of it!!!

Key terms: physical oceanography, dynamics

Practicalities

Instructors:

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TA Huaiyu Wei (huaiyu.wei@connect.ust.hk)

Course grade breakdown:

method	%
attendance	10
assignments	$4 \times 10 = 40$
exams (mid term + finals)	$2 \times 25 = 50$

Practicalities

Method of delivery:

- ▶ Zoom (meeting ID on Canvas) **until further notice**
 - **Tue and Thurs, 1:30pm to 3pm** (open from 1:15pm)
 - possible transition to mixed mode when policy changes
 - join meeting through Canvas ideally (for taking attendance reasons)
 - lectures will be recorded on the cloud and made available ASAP after lecture
- ▶ “office” hours **Wed, 2-3pm** (Zoom ID: 915 4492 8604)
 - extra office hours dependent on availability of TA and/or Instructor
 - ask questions on the Canvas course forum (TA mostly, occasionally Instructor)

Approach of course

What this course is:

- ▶ a **descriptive** intro to topics in physical oceanography
 - bias from me on topics to do with **dynamics** and large-scale circulation

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 - make some plausible assumption, roll with it and see where it leads to
- ▶ focus on getting you to be able to start digesting/using the facts from books

Approach of course

What this course certainly is not:

- ▶ a computation based course on physical oceanography
→ **basic/overall** understanding, but devil is of course always in the details (go to OCES 3203 for the beginnings of that)
- ✓ e.g. **why** you might want to use **potential** over **in-situ temperature** (i.e. θ and not T) (see Lec 6)
- ✗ e.g. **recall the formula for and calculate** potential temperature θ

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- ▶ a complete course on physical oceanography
→ further directions throughout the course notes

Lecture format

Lectures do not follow any particular book:

1. Pickard & Emery, "*Descriptive physical oceanography*" 5th edn
→ I actually hate this book but may suit some (IMO it makes oceanography seem much harder than it needs to be)
2. Talley, "*Descriptive physical oceanography*" 6th edn
→ IMO what the above book should have been, but wasn't...
3. Knauss, "Introduction to physical oceanography", 2nd edn
4. Wunsch, "Modern observational physical oceanography"
5. Williams & Follows, "Ocean dynamics and the carbon cycle"
→ "harder" but really worth it IMO

You shouldn't need anything outside the lecture slides

- ▶ course notes link on Canvas (**continually updated**)

Syllabus

Part 1: Basics

- | | |
|---|--|
| <p>L01 Big picture</p> <p>L02 Terminology + oceans</p> <p>L03 Seas, shelves, estuaries etc.</p> <p>L04 Forces and equations of motion</p> <p>L05 Sea water properties: temperature and salinity</p> | <p>L06 Sea water properties: some thermodynamics + beyond <i>in situ</i> variables</p> <p>L07 Forces: pressure and gravity</p> <p>L08 Forces: Coriolis</p> <p>L09 Forces: Wind</p> <p>L10 Forces: Viscosity and friction</p> |
|---|--|

- ▶ calculus revision in Lec 4
- ▶ fundamentally revolve the concepts of **buoyancy, hydrostatic balance, geostrophic balance**, and theme and variations thereof

Syllabus

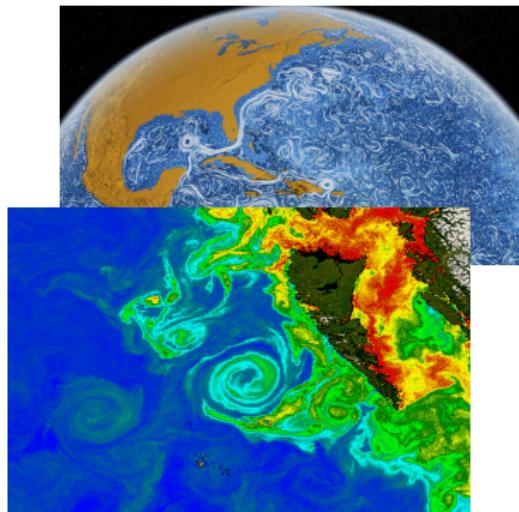
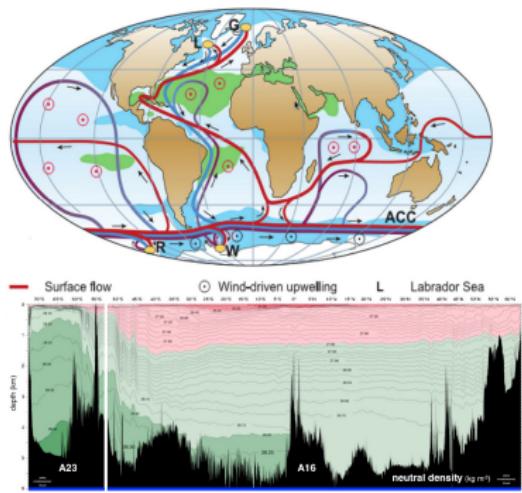
Part 2: Dynamics

- | | |
|---|--|
| <p>L11 Wind driven gyres: geostrophy and Sverdrup balance</p> <p>L12 Wind driven gyres: western boundary currents and vorticity balance</p> <p>L13 MOC: Southern Ocean and ACC</p> <p>L14 MOC: global MOC + boundary currents</p> | <p>L15 Dynamics: intro to waves</p> <p>L16 Dynamics: types of waves</p> <p>L17 Dynamics: instabilities</p> <p>L18 Dynamics: tides</p> <p>L19 Observations: in-situ</p> <p>L20 Observations: remote</p> |
|---|--|
-
- ▶ wind drive gyres theory to demonstrate successes of “**make some assumptions, roll with it and see what you get**” principle
 - you learn from what it tells you AND what it doesn’t!
 - ▶ gyres + MOC highlight controls by small-scale dynamic processes
 - ▶ concepts in smaller-scale dynamics (pictures based)

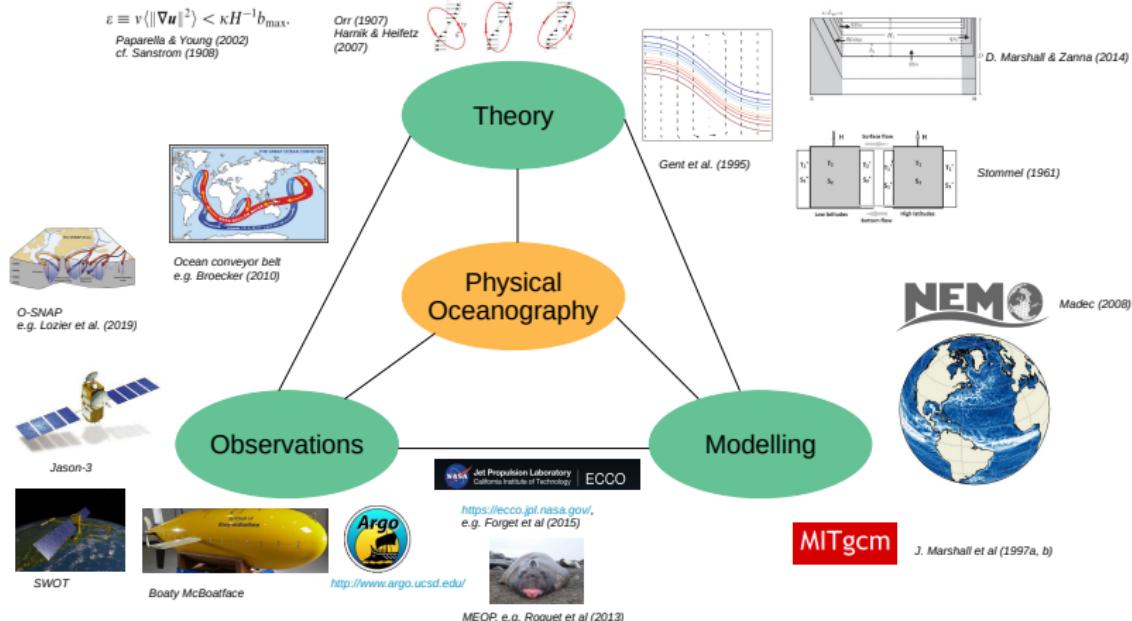
What is physical oceanography?

Study of physical **features** and **processes** of the ocean

- ▶ **what** does it look like?
- ▶ **why** does it look like the way it does?



What is physical oceanography



understanding the ocean require
interdisciplinary + complementary approaches

Earth overview



from <https://sites.google.com/site/climatetypes/>

Ocean

The ocean covers > 70% of the Earth's surface:



- ▶ holds about **50 times more carbon** than the atmosphere
- ▶ upper **2.5m** holds **as much heat** as the atmosphere

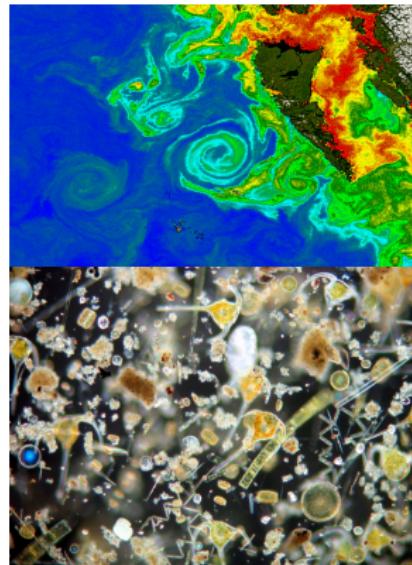
water moves ⇒ **lots/large amounts** of things being moved

Oceans and weather/climate

“holds about 50 times **more carbon** than the atmosphere”

- ▶ some **inorganic** (e.g. carbonates) but largely **organic**

- ▶ role in **carbon cycle + global warming**
- ▶ ocean largely seen as a **sink** for atmospheric carbon
 - physical (e.g. turbulence, **circulation**)
 - biogeochemical (e.g. **biological pump**)

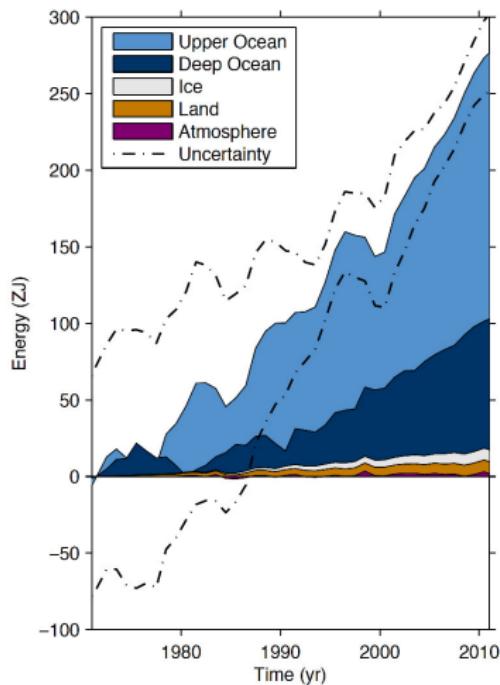


top: false colouring of chlorophyll concentration
bot: from Annegret Stuhr/GEOMAR

see more in e.g. Williams & Follows (2011), *Ocean Dynamics and Carbon Cycle Principles*, CUP

Oceans and weather/climate

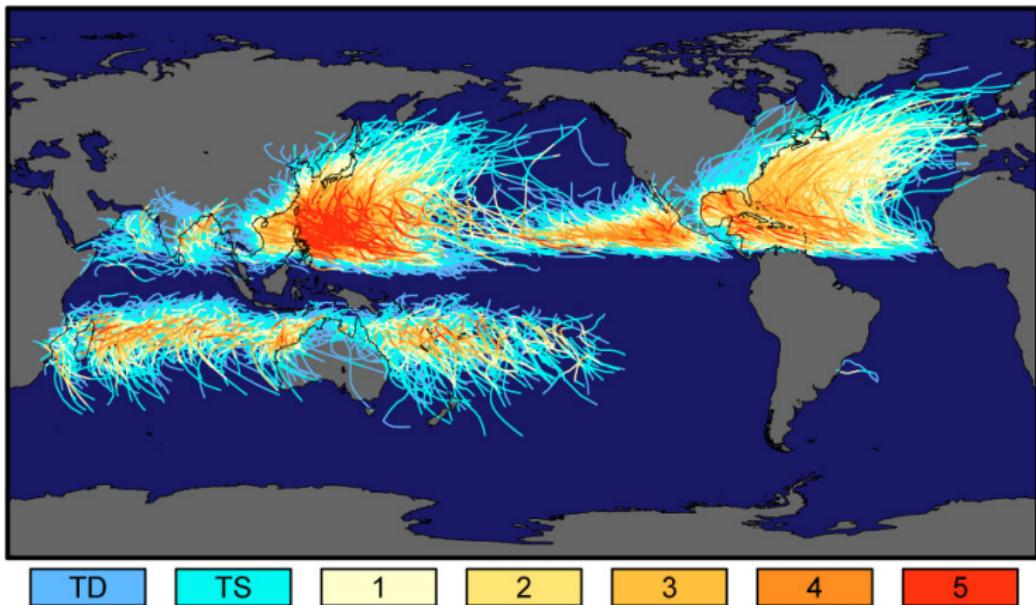
“upper 2.5m holds as much heat as the atmosphere”



- ▶ high heat capacity (see Lec 5)
→ stores excess energy
(measured as Ocean Heat Content) (more in OCES 4001)
- ▶ ocean important part of energy balance
→ Earth tilt, uneven Solar heating (see Lec 5)
→ circulation affects and affected by excess energy redistribution (see Lec 13 + 14)

left: IPCC AR5 (2014)

Oceans and weather/climate



Saffir-Simpson Hurricane Intensity Scale

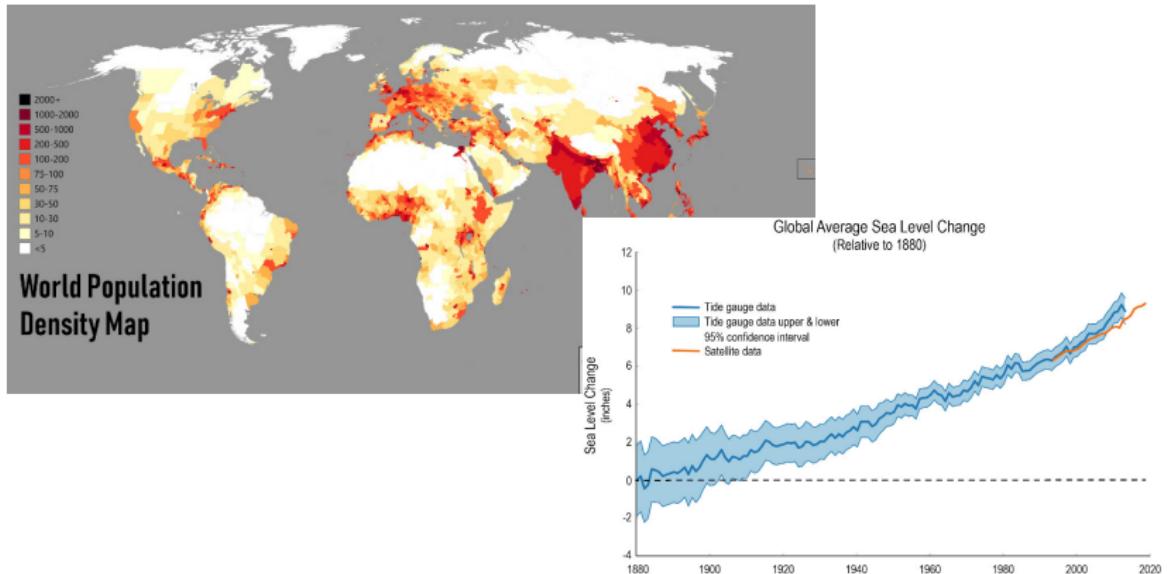
- ocean affects and is affected by the **atmosphere** (see Lec 9 + OCES 4001)

Oceans and weather/climate



video: <https://www.youtube.com/watch?v=ASJSrVBPazw>

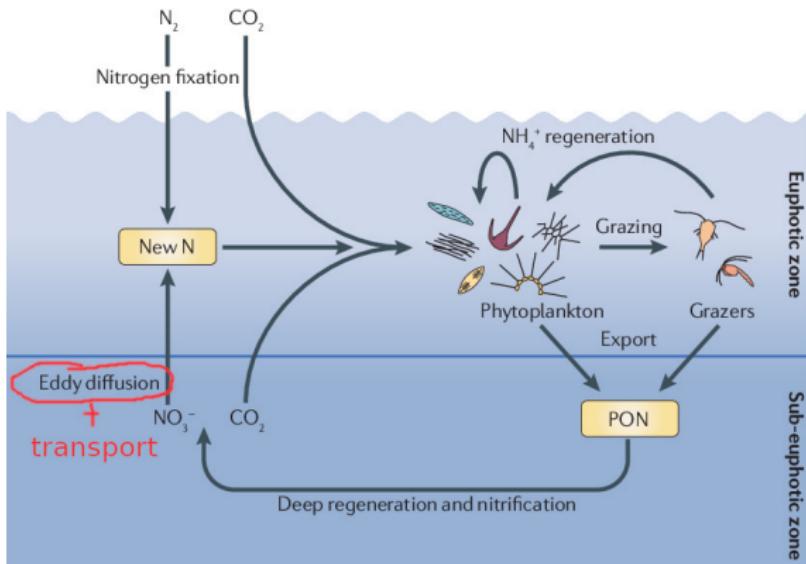
Oceans and weather/climate



- ▶ global warming ⇒ sea level rise
 - **thermometric vs. halosteric** (see Lec 5 + OCES 4001)
 - which sea level (eustatic, dynamic, relative...)? (see OCES 4001 and a bit in Lec 18)

left: reddit user some_dawid_guy; right: from USGCRP

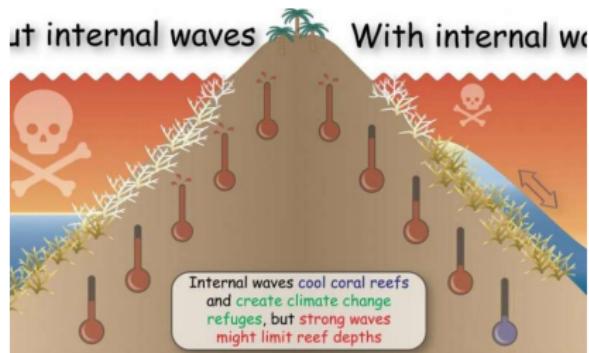
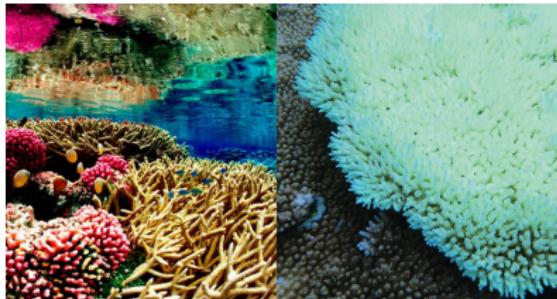
Oceans and ecology



- ▶ nitrogen cycle as an example
- ▶ nutrient supply particularly through physical upwelling
→ wind and/or eddy driven?

adapted from Sohm *et al.* (2011), *Nature reviews*

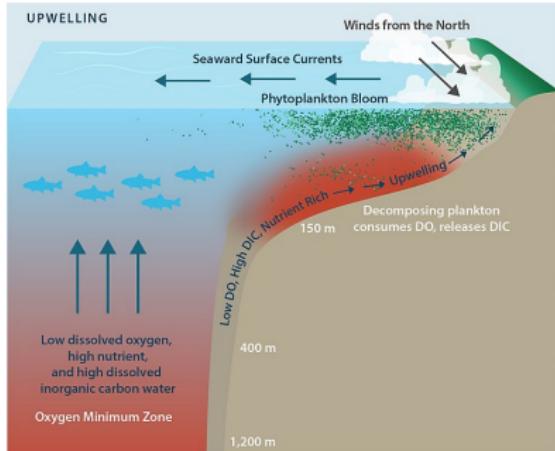
Oceans and ecology



- ▶ environmental stresses on coral reef ecosystems
→ internal waves (see Lec 16) and associated heat relief?

left: Jim Maragos / U.S. Fish and Wildlife Service; right: The Pokémon Company; bot: courtesy of Alex Wyatt

Oceans and ecology



- ▶ **hypoxia** (i.e. low oxygen conditions in water)
 - some naturally occurring (e.g. Black sea see Lec 3)
 - human activity stresses?
 - influences by physical upwelling? (e.g. global warming)
 - ⇒ increased **outgassing**?

left: Gerwin (2010), *Nature*; right: Mobile bay jubilee event + dead stuff, photo from NOAA

Oceans and economy

Blue economy

- ▶ “sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem” – The World Bank

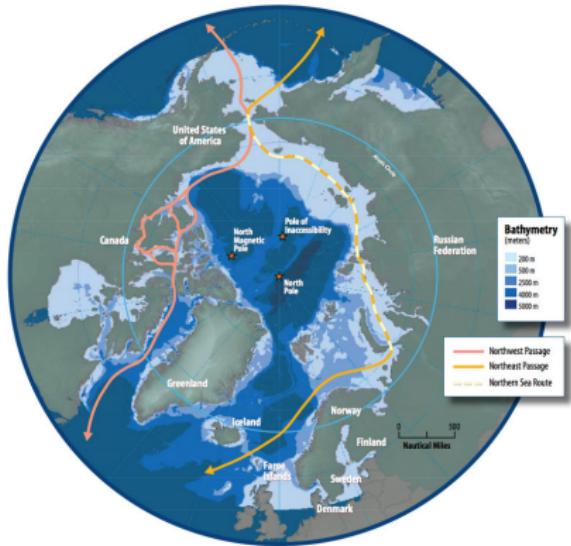


e.g. **fisheries + food security**

- ▶ physics → biogeochemistry \rightleftharpoons marine ecology \rightleftharpoons fishing + fishery management

picture from HK AFCD

Oceans and economy



e.g. **shipping**

- ▶ **weather influences on shipping?**
 - e.g. route planning in South China Sea, one of the busiest regions in the world
- ▶ **climate influences on shipping?**
 - opening up of new routes if ice melts?

- ▶ policy, politics, sustainability etc.

→ physics has implicit influences (not immediate obvious influences maybe!)

image from Wikipedia (Susie Harder - Arctic Council - Arctic marine shipping assessment)

Oceans and economy



Sketch from Tsumoru Shintake (Okinawa Institute of Science and Technology Graduate University)

e.g. **energy security**

- ▶ harness ocean's vast energy for consumption
 - **waves, tidal, geothermal** etc.?
 - design/build equipment
 - how to **optimise** power generation
 - feedbacks and impacts on environment (physical and/or ecological)?

Summary

- ▶ physical oceanography is
 - study of **what** the ocean looks like
 - **why** does it look like the way it does
- ▶ ocean physics drives
 - weather and climate
 - ocean biogeochemistry
 - ocean ecology
 - economy, policy, etc...

Ocean physics is not easy, but you need enough of it!!!

Course structure + approach

Approach:

- ▶ descriptive in nature + focus on dynamics
 - focus on geometric interpretations
 - use a bit of calculus but not examined

Content structure:

- ▶ ocean features we want to explain (Lec 2 - 6)
- ▶ attempt at explaining (Lec 4 - 18)
 - bias on “clean” things
- ▶ how did we get those features anyway (Lec 19 - 20)