<http://highstat.com/index.php/beginner-s-guide-to-generalized-additive-mixed-models>

<https://multithreaded.stitchfix.com/blog/2015/07/30/gam/>

<https://research.csiro.au/ereefs/models/>

Minor Project at AIMS as part of my Masters course through JCU. The project will focus on modelling sub-surface sea temperatures on the Great Barrier Reef.

Pandolfi et al 2011 – review of global climate changes/impacts on coral reefs

* Overall trend = warming
* Temp thresholds are species specific and this can also vary geographically
* Mass bleaching have increased in last few decades
* Recovery is variable with some areas not showing substantial recovery after 5-10 years
* Possible projection for future coral reefs
  + Changes to species composition because of species specific reactions
* Suggests that reef degradation due to CC alone will be more heterogeneous than projects suggest now
* Indicates that controlling local factors is the best management strategy to allow reefs to adjust to global changes

Hughes et al 2017 - hughes closes the door on all of the hopeful thoughts Pandofli had above

* Recurrent bleaching events – increased severity
* 2016 was the largest and most severe bleaching event on the GBR known
  + >60 of corals bleached
  + Reefs surveyed >90 had some level of bleaching
  + 30% of reefs had between 8-16 DHW
  + Southern part of the reef bleaching was less severe due to local weather conditions (tropical cyclone caused cloud and rain cover which resulted in a 3o drop
  + 32 first time reefs bleached compared to 10 and 9 in 1998 and 2002, respectively
* Only 9% of surveyed reefs have never bleached, 26% bleached once, 35% have bleached twice, 58 second time was 2016 compare to one between 1998/2002 and 29% bleached all three times
* Local factors did not influence bleaching, eg fished or protected zones, water quality but could improve future recovery
* Past bleaching did not have a protective effect for future bleaching
* Severe bleaching is homogenous but at lower severity it can be selective
* Biggest issue is the frequency of severe heatwaves – reefs ith out recent temperature damage are decreasing

Hoegh-Guldburg

Maynard et al 2008

* Created improved models to predict the severity of bleaching events.
* Wanted to improve three factors that reduced the accuracy of DHD on a local scale
  + Temperature is highly variable on reefs locally
    - By increasing the resolution of SST from satellites (to 1-2 km, grid: 0.018o, climatology resolution: 0.042o) using a 14-day mosaic
  + DHD/W is accumulated time (day/weeks) above a temperature threshold but doe not consider the rate of temperature increase. Eg , three weeks at an increase of 1 is the same as a 3 increase for one week, the latter would eb more stressful to organism as there would be a greater phycological toll from the rapid short live increase (much less chance for acclimation.
    - Include a calculation of the heating rate as well as the accumulated days
    - LMST = long-term mean summer temp
  + the max threshold is the same throughout the year
    - the max threshold should vary seasonally
* these were found to improve the accuracy of severity prediction

Garde et al 2014 – ReefTemp Next Generation

* the original RT used BOMs 14-day advanced very high-resolution radiometer mosaic of SST

new RT uses daily SST satellite data from IMOS

* + new resolution of 0.02o x
* original RT produced data on SST, SST anomaly, DHD and heating rate.
  + The new RT asl includes: quality level (assess the quality of measurement due to interruptions from cloud cover, gap analysis, single sensor error statistic bias, DHD count, mean positive summer anomaly and grid age using both 1-day IMOS SST and 14-day mosaic SST (Table 2).
  + calibrated with in situ temperature of ocean skin (10-20 um) completed at night to reduce influence of

Robson et al 2017 – Evaluating the eReefs model agains observed emergent properties

Not a temperature focused paper but does go into detail about the eReefs model overall

* further eReefs explanations
  + Herzfeld et al 2016
  + Baird et al 2016
  + Chen et al 2013 (vision for eReefs)
  + Car 2013
  + Yu et al 2016
* Earlier eReefs papers
  + Margvelashvili et al., 2003
  + Robson et al., 2006
  + Webster et al., 2006
  + Webster et al., 2003
* eReefs is a process based model, therefore predictions can be made about the process of the features, not just the features
* overall the eReefs models are work well, and in the case of patterns and underlying processes are effective.
* Futher work on process based modelling is encouraged.
* \*compare the trends of temperature profiles for modelled and collected data\*

Outline for Lit Review

* Modelling temperature to predict impacts of anomalies
  + eReefs (ReefTemp??)
* Importance of groundtruthing/cross validation models (glider data)
  + Using different depths
* Heatwaves/degree heating days/weeks
* Heatwaves impacts on corals

Step 1.

Get glider data and find the best way to compare with model predictions of profiles.

* What locations/time to focus on?
  + Probably should be somewhat randomized?
* If fuzzy verification was used
  + Option for model view or user view
    - Observation scaled up to represent scales from model or to verify predicted values from selected locations, respectively.
  + Unsure how it would work in a 3D environment eg profiles are from a selected time and space but increasing depth cannot turn the depth into a grid for fuzzy verification – Could I use single observation-neighbourhood forecast for a selected depth?
* What methods to use?
  + Best Groundtruthing/comparison methods
    - root mean squares
    - mean absolute errors
    - correlation coefficients
* biggest problem is timing need the model and glider temperatures to match time-wise

Step 2.

Once the accuracy of ereefs at depth is known can create new GAM with a range of other factors and predict temperature at selected depths

* What depths to focus on?
  + Need to be biologically relevant
* Other factors
  + Location, time of years, wind
* Best cross validation methods
  + K-fold 5 or 10 is generally the best CV selected

Step 3.

Can create maps using the GAM, over the reef at selected depths from predicted heatwave conditions

* Are there areas at different depths less impacted by marine heatwaves?
* Long-term warming patterns and the overall risk/impact to reefs
* short term temperature effects == heatwaves (increased intensity, frequency and longevity)
* direct impact of heating to coral == bleaching and mortality

the first part will lay out the background information (in detail) and why this work is important to study heatwaves on coral reefs in

* Modelling temperature == the types of model, how they were created and validated
  + eReefs
  + ReefTemp
  + Models used for other reefs
  + Satellite algorithms
* Subsurface == SST and sub-surface temperature predictions
  + Effectiveness
  + How others have adjusted these models

the second part leads closer to my research questions: comparing and creating models for the subsurface.